SCIENTIFIC AMERICAN

No. SUPPLEMENT 677

Scientific American Supplement, Vol. XXVI., No. 677.
Scientific American, established 1845.

NEW YORK, DECEMBER 22, 1888.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE SALMON FISHERIES OF THE COLUMBIA RIVER.*

THE salmon family embraces many varieties. They are deep-sea fish which spawn in fresh water. It is during the months of spring and summer of each year that the mature fish enter fresh water rivers and seek their spawning grounds, where nearly all of them die shortly after spawning; and it is while they are entering the rivers or are proceeding up the same that they are caught for commercial purposes, thus developing the salmon fishery. They begin running up the Columbia River in April and May, and continue running until October. As the salmon passes up the river and approaches the spawning ground, it begins to deteriorate in quality for food purposes. The long abstinence from food and continued exertion of running many rapids make it thin and poor in flesh. As the spawning period approaches, the most extraordinary changes take place, making the fish wholly unfit for food. While the evidence is conclusive that from some rivers the salmon returns to the sea after spawning, it is almost conclusive that those of the Columbia River do not return, but die upon or near the spawning grounds. A young hatched salmon is a jelly mass, without shape, hanging to the egg-sack, from which it derives its nourishment. At this stage it is perfectly helpless and falls an easy prey to older fish. While the eggs are being spawned other fish collect around and eat them with avidity, the male fish at the same time endeavoring to fight them off. When the yolk sack is absorbed the young salmon begins to feed, rising greedily to seize any minute object floating upon the water.

It has not yet been ascertained at what age the fish mature. Chinook salmon, with fully matured spawn, are caught in sizes ranging from 2½ to 60 pounds in weight, and as it is believed that the salmon of the Columbia River spawn only once on reaching maturity, it seems probable that they mature at different ages. The observed facts, however, bearing on this point are entirely insufficient to base conclusions upon.

Facts tend to show that all salmon go down the river with their heads generally pointed up stream, and that, owing to some peculiarity of structure, they cannot swim for any distance with a strong current, but are obliged to float down with it.

The following species run in the Columbia River:

THE STEEL-HEAD—SALMO GAIRDNERI. (FIG. 1.)

This species is everywhere known as the steel-head. The name hard-head is sometimes applied to it, and it is known to the Russians as "Seomga."* The name "Mykiss" is said to have been formerly applied to it in Kamtchatka. Large individuals are often called salmon trout. The Indian name "Humaana" is said to be given to it on the Upper Columbia. It reaches a weight of 22 pounds, the average weight when fully grown being about 16. Young specimens are very scarce. It is found from Monterey to Kamtchatka, always close to the coast. In the Columbia and Frazer Rivers it occurs in abundance in the spring at the time of the salmon run. None have yet been noticed to the eastward of the Cascade Range, and so far as appearances go, it is a permanent inhabitant of river mouths. It probably spawns late in the fall or in the winter, as many of those taken at the first run of the salmon are spent fish, with the flesh white and worthless.

Elsewhere than on the Columbia this species is highly valued as food fish. When taken in the Columbia in spring little or no use is made of it. Its flesh is pale and its bones are too firm for it to be used in canning, and at that season the old individuals taken are usually spent and worthless. In the Sacramento it is not very common.

THE DOG SALMON—ONCORHYNCHUS KETA.

This species, during the period of its run in the fall, generally goes by the name of dog salmon, under which name the males of the silver salmon and even of the quinnat are often confounded with it. The Russians now, as in the time of Pennaut, Pallas, and Walbaum, call it "Kayko," the name "Keta" (whale) being no longer in use. On Frazer River the name (Musquam) is now "Qualoch;" at Seattle (Nisqually) "Ktla-why," and in the Chinook jargon, "Le-Kai." This species is very uniform in its size and averages 10 to 12 pounds. It ranges from the Sacramento River to Behring Strait, where it seems to be especially abundant, it being the only salmon brought from there in a recent cruise of the revenue cutter Corwin. It is seldom or never seen in the rivers in the spring.

THE BLACK-SPOTTED TROUT—SALMO PURPURATUS.

This fish is known as the trout, mountain trout, spotted trout, black trout, silver trout, etc., in the mountains, but when in the ocean full grown, as salmon trout, or steel-head. The Indian name, Preestl, is also ascribed to it on the Upper Co-

FIG. 1.—BLUE-BACK AND STEEL-HEAD SALMON.
(Steel-head on left.)

FIG. 2.—CHINOOK SALMON (ONCORHYNCHUS CHOUICHA).
(Male, and female on left—45 and 40 lb.)

* Abstract of a report upon this subject made to the Secretary of War by Major W. A. Jones, Corps of Engineers, U. S. A., in response to a Senate resolution of Jan. 27, 1887.

* Called also "pumpkin seed."

lumbia. It reaches a weight of thirty pounds under the most favorable circumstances, but may be found in any stream or lake of any length from two inches up to two or three feet. Unlike *S. Gairdneri*, the young are very common, and it probably begins breeding in mountain streams at a length of less than a foot. It is universally distributed through the Rocky Mountain region, chiefly east of the Sierra southward, but reaching the sea from Mount Shasta northward. It occurs in every lake of New Mexico, Utah, Western Colorado, Wyoming, Montana, Idaho, Oregon, and Washington.

Every stream throughout the most of this region abounds in them, and in Puget Sound the young of every size occur in the salt water in abundance. Individuals are occasionally taken along the California coast. Local variations occur in abundance. Specimens from Seattle have the scales notably larger than those from Victoria and Astoria, which agree with Utah Lake specimens in this respect. Those that live in the depths of shady lakes are almost black, while others are pale. Those in the sea are silvery and only faintly spotted. Only in Lake Tahoe do the variations assume any marked importance (var. *Henshawi*). Individuals intermediate between this species and *S. Gairdneri* are not rare, and there is no doubt that the latter is simply an offshoot from this general stock, as are *S. irideus* and *S. stomias*. It feeds on any living thing it finds near it.

THE HUMP-BACKED SALMON—ONCORHYNCHUS GORBUSCHA.

This species is known to the Russians still, as in the time of Pennant and Pallas, by the name of gorbuscha, gorb meaning hump. The English-speaking people call it generally the hump-backed salmon, and often the dog salmon. On Frazer River it is known as holia, or hone salmon, and on Puget Sound as the haddoh. This is one of the smallest salmon, not averaging over four or five pounds, and probably never exceeding ten. It ranges from the Sacramento River to Alaska and Kamtchatka. In the Sacramento and Columbia it is only an estray, on the latter river being sometimes called lost salmon. In Puget Sound it runs in large numbers in late summer and fall, like the keta or dog salmon, ascending every little stream. Its run in Puget Sound takes place in alternate years, a fact which seems to be well established. During its run in Puget Sound the females are canned and the males are thrown away or given to the Indians. The flesh is then pale, and the canned product is inferior in quality. In economic value the hump-backed salmon is far inferior to the quinnat, the blue-back, and the silver salmon, and, like the dog salmon, is mainly useful in furnishing a winter supply of food to the Indians.

THE SILVER SALMON—ONCORHYNCHUS KISUTCH.

This species is almost everywhere known by the name of silver salmon. It has also a series of local names. In Kamtchatka it is still known by the name kisutch, in use in Pennaut's time, a hundred years ago. The name bielaya-ryba, or white fish, is also ascribed to it. On Frazer River it is known by the Musquam name of coho; at Seattle, by the Nisqually name of skowitz; about Cape Flattery, by the Makah name of hoopid; on the Columbia it is called silver salmon, or white salmon, and southward the same names prevail. It reaches a weight of twenty pounds, the usual range being from seven to ten. The silver salmon enters all the rivers from the Sacramento to Kamtchatka. In the fall it is abundant in probably all the rivers. Few or none, however, are seen in the spring. They are often taken with seines in Puget Sound at all seasons. Like the other fall-running salmon, it seldom ascends the rivers to any great distance.

THE BLUE-BACK SALMON—ONCORHYNCHUS NERKA. (FIG. 1.)

This species is known as the red fish to the English-speaking inhabitants of Alaska and Kamtchatka, and to the Russians now as in the time of Pennant and Pallas as Krasnaya ryba, which signifies red fish, the name having reference to the color of the flesh. It is not unlikely that other species are occasionally confounded under this name, but there is little doubt that the present species is the one to which it is chiefly applied. On Frazer River, where this species is the most important salmon, it is known as the suk-kegh. Elsewhere in Puget Sound it is rarely seen. On the Lower Columbia it is known by the appropriate name of blue-back; on the Upper Columbia as red fish. Its average weight does not exceed eight pounds, and its extreme weight is probably not above fifteen. Its range is from the Columbia River to Japan and Kamtchatka. It runs in considerable numbers in the Columbia, and in much greater abundance in Frazer River, where it is the principal spring salmon. Like the quinnat salmon, it is attracted in early spring into all those streams which are fed by the melting snows, and into no others. Its run in spring on the Columbia is, so far as known, cotemporaneous with that of the quinnat salmon. Next to the quinnat it is the most valuable of the different species, and is inferior to that in size only.

THE QUINNAT OR CALIFORNIA SALMON—ONCORHYNCHUS CHOUICHA. (FIGS. 2 AND 3.)

In Alaska and Kamtchatka, writes Jordan, "This species is known as the King Salmon," and as "Chowecha," or "Tchawytcha," a name easier to pronounce than to spell, to the Russians. In Frazer River it is called by the Musquam name of "Sah-Kwey;" in Puget Sound it is called the "Columbia River Salmon," or in the Chinook jargon "Tyee." On the Columbia River the name "Chinook Salmon" is in universal use. Further south the name "salmon" is applied to this species, while the others receive specially distinctive names. The Quinnat salmon reaches a weight of 60 to 90 pounds, being the largest of the salmon family. The average weight is, however, much less. On the Columbia River the average is 22 pounds each; on the Sacramento River, about 16. It is probable that the individuals of about 20 pounds weight are four years old, and the larger ones occasionally taken are older, having probably lived through one or more spawning seasons. Those which enter the river late in the fall cannot ascend far before the necessity for spawning comes, and such may be able to return to the sea, and thus escape the death which overtakes all that spawn inland.

In all streams having their rise in the snows, this species begins running as early as March, and the run continues with various interruptions until the spawning time in the fall. When a freshet occurs in spring, the run for a time after is much increased. In regard to this species and the blue-back, it would appear that they, when adult, enter the streams whenever cold fresh water comes in contact with them in the sea.

The California salmon is a remarkable fish and has had an extraordinary career. Fifty years ago it was hardly known except to students of natural history. Now it is known and eaten almost all over the world, for there is hardly a port in the world where ships have not carried the canned salmon of the Columbia, which is the same fish under a different name; and not only has this fish, in the form of food, traveled nearly all over the world, but the living embryos of the California salmon have been transported to England, France, Germany, Denmark, Belgium, Russia, Australia, and New Zealand, so that there is probably no one fish inhabiting a limited locality which is known all over the world in so many different places as the California salmon.

This magnificent fish is deserving of its career. Of splendid proportions, of unsurpassed vigor and spirit, it has no equal in external attractiveness among the race of fishes except its own cousins of the Atlantic and other oceans, while as regards the quality of its flesh and its marvelous abundance in its habitat, it has but few equals in the world. As to the quality of its flesh, it closely resembles the highly prized salmon (*Salmo salar*) of Great Britain and the Atlantic coast of North America, which has no superior; and as to its abundance, it need only be said that nearly 200,000,000 pounds have been caught in the Columbia River alone during the last six years, without producing, according to the most recent testimony of the Columbia fishermen, any serious diminution of the river's stock.

This species is the only salmon protected by law.

JULY STEEL-HEAD—SALMO TRUNCATUS.

The July steel-head is so called on account of the hardness of its bones and the month in which it runs. This is not generally used for canning, on account of its light colored flesh and hard bones, but is fair, either fresh or salted. It differs from all other species in having a short head, a long, slender body, which tapers less than other species toward the square tail, and entrails covered with fat. The principal spawning grounds are the Snake and its tributaries and the Yakima.

WEAK-TOOTHED SALMON—SALMO PAUCIDENS.

The weak-toothed salmon appears in large numbers about the last of May. This fish has been mistakenly classed by the fishermen of the lower river as a young Chinook salmon or grilse. Its average weight is about twelve pounds, and it ranks fourth commercially.

WHITE SALMON—SALMO TSUPPITCH.

The white salmon, so called from the color of its flesh, passes up the river about the last of July. It averages about fourteen pounds in weight, but it is worthless as food, on account of the strong, unpleasant taste of its flesh.

UNCLASSIFIED SPECIES.

A species of salmon not well known, not classified, and of no commercial value, makes its appearance with the blue-backs. It is of a reddish brown color, marked with black crescent-shaped spots, has large teeth and a hooked nose, and reaches the weight of sixty pounds. The Upper Columbia is its spawning ground.

Another species not well known, on account of but few being caught, has the reddest flesh of any of the salmon family. It is of no commercial value, because of the poor flavor of its flesh. On account of its having no scales, it might be called the leather salmon. The other red or pink fish in the river belong to the trout family.

OCEAN HISTORY.

Very little, almost nothing, in fact, is known of the ocean history of the salmon. We know that the fish leave the mouths of the rivers at stated times and return to their rivers at other stated times, but whither they go or how they fare, or what motives guide their course in their mysterious ocean sojourns, no one knows. From analogies derived from our knowledge of the history of the Atlantic salmon, it may be supposed that they go into deep waters, when they leave the rivers, and seek the best feeding places that they can find, but that is about all that can be said of their ocean history. They are found to have deep-sea fish in their stomachs when they first make their appearance near enough to the mouths of the rivers to be captured, and this points to the deep sea as their ocean feeding ground. They are rarely ever caught or observed at sea.

(To be continued.)

FIG. 3.—CHINOOK SALMON. (Young male on right.)

RUSSIAN METEORITE AT NOWO-UREI.

THIS meteorite, which fell September 22, 1886, near the village Nowo-Urei, government of Pensa, Russia, is unique in containing carbon in the form of diamond. Three stones were known to fall, of which two were found. The external appearance did not differ from ordinary meteoric stones, and on the fracture they appeared of a dark gray color, and showed the presence of the chief constituents—olivine, augite, and nickeliferous iron. In the course of the analysis, from

2 to 2·5 per cent. of the material taken remained unattacked by acids, and of this, 60 per cent. was amorphous carbon and 40 per cent. resisted fusion in bisulphate of potash. The residue was in the form of light gray grains; it proved to consist of 89·6 carbon and 10·4 per cent. ash, and had a specific gravity of 3·1; the hardness was sufficient to scratch corundum readily. It was consequently concluded that the substance must be ordinary diamond or the massive form carbonado. An analysis of the whole stone gave:

Fe (Ni)	Cr_2O_3	Fe_2S_3	C	Silicates
5·47	0·95	0·43	2·26	90·76–90·87

The diamond-like carbon made up about 1 per cent. of the whole. The silicates consisted essentially of olivine and augite in the ratio of 67·5 to 23·8. In amount of carbon this stone is exceeded only by that of Orgueil, which gave 4·1 per cent. in form of a humus substance. As regards the occurrence of the carbon in the diamond form, the only related cases are those of the Arva iron, in which Haidinger found cubic crystals of a graphitic substance with apparently pyritohedral planes, and which Rose suggested might be pseudomorphs of graphite after diamond; and the related graphitic mineral cliftonite, from the meteoric iron of Youngdegin, W. Australia, recently described by Fletcher.

[GARDEN AND FOREST.]

WHEN AND HOW TO PRUNE GRAPEVINES.

NOTWITHSTANDING all that has been said and written about the numerous systems of pruning and training the vine, few operations of the garden are practiced with so little intelligence. Many professional gardeners need no instruction in this matter, and others are above receiving it. But to amateurs and novices it may be well to say that the chief point to remember is that the cane-producing fruit next year is grown on this year's cane.

February was formerly considered the best time to prune grapevines, but of late years fall pruning has rapidly grown in favor, and November is now chosen for this work by expert vine-dressers. The milder weather that is apt to prevail and the absence of snow make it far more comfortable for the operator, and vines that have been overtaxed and failed to mature their fruit can be treated with better judgment when their condition is fresh in the owner's mind than if the work is deferred till February, when their condition may have been forgotten.

Another reason for fall pruning is that the removal of surplus wood allows the vine to devote all its energies to more thoroughly ripening the remainder. The maturing and hardening of the wood is not complete when the leaves fall, neither is all wood apparently ripe sufficiently so to pass the winter uninjured. This winter killing of the young and immature wood is the strongest argument in favor of winter pruning, its advocates claiming that no mistake can be made then, as all wood that has safely passed the winter up to that period will continue to live. This is true, but the loss of any wood after pruning is generally too insignificant to be worth considering.

Unless these canes have attained a diameter of three-eighths of an inch or more, they should be cut back and the process repeated till they acquire that size. Vines thus treated will make canes of much greater value than if they had been allowed to grow and had been left to themselves.

The lateral branches that start on these canes should be shortened in to one leaf as they appear, thus forcing the energies of the plant into the main canes.

The vines are generally ready for trellising and training on any system that is decided upon the second season after planting, and may be allowed to bear a bunch or two of grapes. Many persons are so anxious for fruit that they allow the young vine to overload itself, and thus receive a check from which it often takes years to recover.

The vigor and growth of vines vary so widely in different varieties that some require closer pruning than others, and it is on this point that intelligence and judgment are needed. Short pruning gives increased size and fine clusters in a small space. Doubling the space may result in doubling the number of clusters, but not the weight of the crop.

The ground where vines are planted should be naturally dry or made so by drainage, and sufficiently fertile to insure a good growth. Those who have doubts on this point often propose to dig in plenty of stable manure, to which I say, No! unless it is thoroughly decomposed. Otherwise put it on the surface as a mulch and the fertilizing properties will find their way to the roots. Coarse or fine bone can be placed in direct contact with the roots without injury, and almost any of the standard commercial fertilizers may be worked into the soil at planting time, but unfermented manures should be placed on the surface.

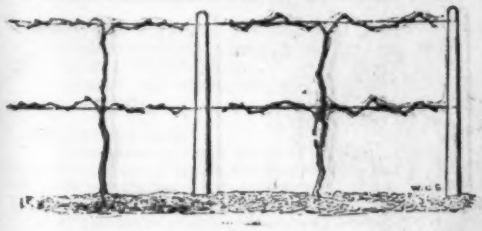


FIG. 1.

The best vines to plant are those one and two years old, the roots of which should be shortened in to about ten inches in length. When older vines are wanted by impatient people, they should have been transplanted yearly, so as to be supplied with well branched, fibrous roots, which this shortening-in process secures. Such vines, properly planted, will bear a full crop earlier than the younger ones, but, in two or three years, the latter will overtake them. A stake should be set with every vine, and one or, at most, two shoots allowed to grow the first season; they should be tied to the stake at intervals.

What is known as the Kniffen system of training, and its improvement, are the simplest of any I have ever tried, and they have, therefore, become more widely adopted perhaps than any other.

The cut (Fig. 1) illustrates the system at a glance. The vine on the left shows the original idea, pure and simple; that on the right the improvement, which consists of growing two trunks, from near the ground. The sap being divided there, each head must get its allotted portion, while in the other case the upper head would be apt to get the lion's share on account of its tendency to flow to the highest point. The arms, which are renewed every year, being in a horizontal position, the buds start with more general uniformity than if they were more upright. The trellis is inexpensive, and is adapted to vineyard or garden. In the latter, wood slats can do duty instead of wires.

Fig. 2 gives a view of a vine as it appears before

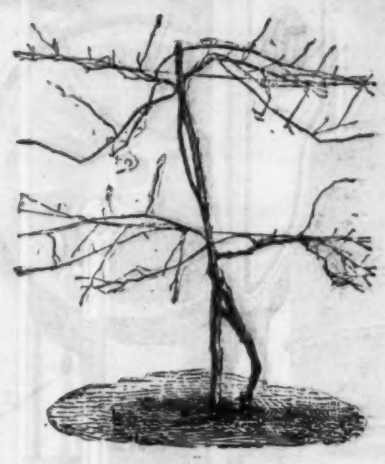


FIG. 2.

pruning, and Fig. 3 the same vine after pruning. The canes forming the arms are the ones nearest the trunk of the vine, and are cut from five to eight buds long. If longer, the buds nearest the trunk would be apt to start too feebly, and fail to acquire sufficient vigor for next year's arm; but if only five or six buds long, a very uniform growth is obtained. By stopping the growth of these young canes at the second or third leaf beyond the last cluster of fruit, the size of the cluster and canes is increased, and the base buds are fully developed, so that the one nearest the trunk generally makes as good a cane and produces as good clusters as those farther away; and the fruit year after year is kept in a small area near the trunk of the vine.

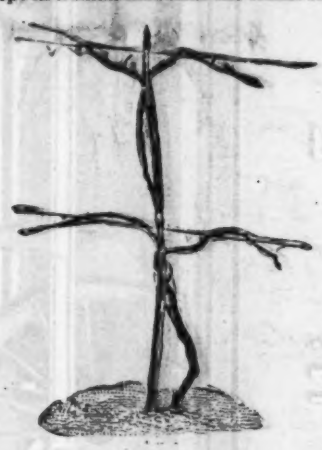


FIG. 3.

The chief objection to the system is that the wind and rain will sometimes break off the tender shoots while young and growing rapidly. To prevent this I have used an extra wire six inches above the arms, to which the young canes are secured, thus preventing any loss from this cause. I have taken this fall from single vines thus trained from twenty to thirty pounds of fine fruit, which satisfies me entirely as to quantity.

E. WILLIAMS.

Montclair, N. J.

[THE PHARMACEUTICAL JOURNAL.]

MARGOSA OIL.

By C. J. H. WARDEN, Chemical Examiner to the Bengal Government.

MARGOSA oil is the oil extracted from the almonds of the Melia azadirachta, natural order Meliaceæ, a tree common in India, and known under the name of "nim." The bark, leaves, fruit, and oil are held in high esteem by native and many European practitioners as remedial agents of value, a tincture and a decoction of the bark and a poultice of the fresh leaves being officinal in the Pharmacopœia of India. Preparations of the bark are considered effectual as antiperiodics, chiefly in the milder forms of periodical fever, and as tonics in convalescence after febrile and inflammatory affections.* The poultice of "nim" leaves is a common domestic remedy with natives, and is used as a stimulant application to indolent and ill-conditioned ulcers. The oil is used as an external application in rheumatism and as an anthelmintic, and is reported by Dr. A. Hunter to be an insecticide.†

Margosa bark was examined by Cornish in 1857,‡ who isolated an alkaloid, which he described under the name of "margosin." The later researches of Broughton,* however, indicate that Cornish's bitter alkaloid is probably an amorphous resin. From the bitter oil of the seeds Cornish extracted an acid which he termed "margosic acid," but which he doubted to be capable of affording crystallizable salts.† Lepine,‡ who examined the oil, found it to have a specific gravity of 0·921, and he describes it as possessing a bitter taste and a garlic-like odor, to congeal at + 7° C., and to yield by saponification 35 per cent. of fatty acids melting at 30° C. and 65 per cent. melting at 44° C. Subsequent writers on Indian materia medica have quoted Lepine's results, but as far as I am aware no additions to Lepine's results have been published.

The margosa oil used in the investigation described in this communication was obtained by expression in my laboratory; there can therefore be no doubt regarding the genuineness of the sample. The fruit was washed to separate pulp, the stones dried, cracked, and the almonds exposed to a gentle heat for some time to remove moisture. The dried almonds were then crushed, placed in a cloth bag, and the oil expressed. It was found very necessary to first dry the almonds before subjecting them to pressure; without adopting this precaution a white, creamy fluid was obtained, instead of clear oil, from which it was subsequently impossible to separate the oil, except by ether or other solvent.

The oil thus obtained was filtered through filter paper before it was examined. Directly after filtration the oil, when viewed in bulk, had a slight greenish coloration by transmitted light, owing to some of the almonds not having been quite ripe and to solution of traces of chlorophyl in the oil. Viewed in a thin stratum, the color of the oil was yellowish. The oil possessed a powerful garlic-like odor, and was very bitter. The specific gravity at 15·5° C. was 9235; at about 10°—7° C. the oil congeals, without losing its transparency. After standing for about thirty-six hours the recently expressed oil deposited a white sediment, which, examined microscopically, was found to be amorphous.

The color reactions of margosa oil were not characteristic. With concentrated sulphuric acid a rich brown color was yielded, and a strong garlic odor evolved. By Massie's test with nitric acid, the oil became almost immediately of a reddish color; after standing about one hour and thirty minutes the color was pale yellow. The elaidin reaction, conducted according to Pontet's directions, yielded a solid, firm, yellowish product after eighteen hours, the temperature in the laboratory varying between 69° and 93° F. Exposed in a thin layer on a glass plate to a temperature of 100° C. for some days, the oil did not dry or become tacky. The oil was easily soluble in ether, chloroform, carbon bisulphide, benzole, etc. Absolute alcohol agitated with it was colored greenish; on separating the alcohol, and evaporating off the spirit, an extract was obtained which consisted of oil, from which a small residue, whitish in color, separated on standing. The alcoholic extract was very bitter and possessed in a marked degree the peculiar odor of the oil. The whitish residue deposited from the oil, separated by alcohol and examined microscopically, did not appear crystalline. Margosa oil, after repeated agitation with alcohol, was found to have lost its bitterness and almost wholly its alliaceous odor.

A known weight of the oil was saponified with alcoholic potash, the alcohol completely evaporated off, and the soap dissolved in water. On agitating the aqueous solution of the soap with ether, 1·00 per cent. of ether extract was obtained of an orange-yellow color and bitter. This extract treated with 60 per cent. alcohol left a small amount of white residue, which had the character of a wax. The aqueous solution of the soap, after separation of the ether, was heated for some time to remove dissolved ether, the solution was then mixed with dilute sulphuric acid in excess, and the insoluble separated from the soluble fatty acids in the manner recommended by Allen.§ The soluble fatty acids amounted to 3·519 per cent., the insoluble to 99·128 per cent. The volatile acids consisted of butyric and a trace of valeric acid. During the distillation to separate the fluid from the volatile fatty acids, a small amount of a snow-white fatty acid passed over; this acid had a melting point of 43·6° C., which corresponds with the fusing point of lauric acid. A weighed portion of the insoluble fatty acids, from which the lauric acid had not been separated, was dissolved in alcohol, and titrated with normal standard soda, using phenolphthalein as an indicator, 0·288 gramme of the acids required 1 c. c. of caustic soda for neutralization. No attempt at separating the fixed fatty acids was made; they probably consisted of a mixture of stearic and oleic acids, with a small amount of lauric acid.

Examined by Reichert's distillation process, 2·5 grms. of the oil gave a distillate which, after separation of the lauric acid, which had distilled over, required 4·6 c. c. of decinormal soda for neutralization, phenolphthalein being used as an indicator.

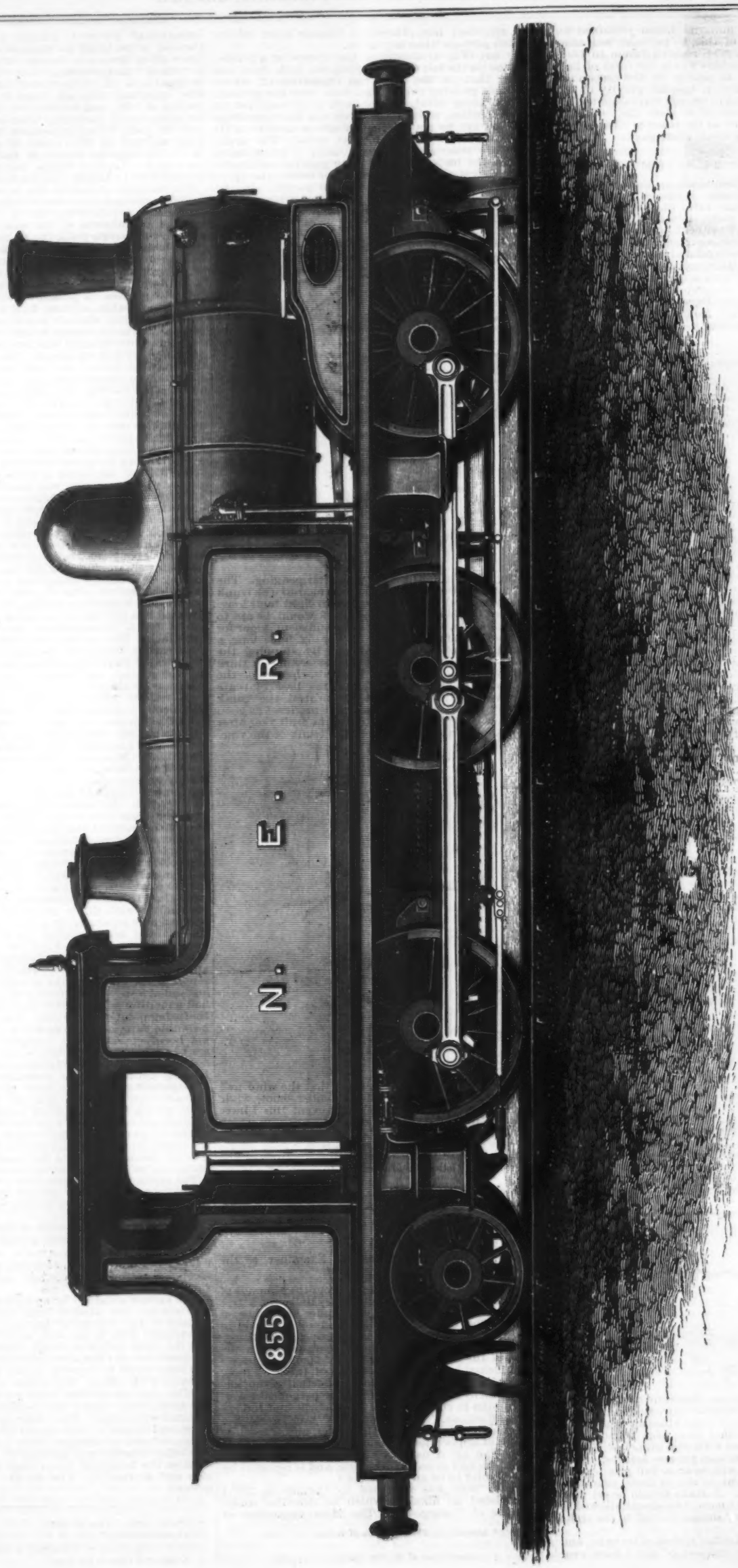
The saponification equivalent of the oil was determined by Koettstorfer's method, and was equal to 284, the percentage of caustic potash required to saponify the oil being 19·73.

A preliminary examination of the oil having indicated the presence of sulphur, a quantitative estimation of the amount present was made, and found equal to 0·427 per cent. The oil, after repeated agitation with alcohol, was found to contain only 0·109 per cent. of sulphur.

The extract obtained by agitating the oil with absolute alcohol has already been referred to; it was examined in the following manner: The oily extract was treated with 60 per cent. spirit, allowed to stand, and the clear, yellow alcoholic solution decanted from the insoluble oil; the alcoholic solution thus obtained was evaporated to dryness, mixed with ammonia, and agitated with ether. The ether solution was marked A. The aqueous solution, after separation of the ether, was mixed with dilute hydrochloric acid, and again agitated with ether. The ether separated of a yellow color, and below it some flocks of a dirty yellow hue, which refused to dissolve after prolonged agitation. The ether solution was marked B. From the aqueous solution the insoluble flocks were separated by filtration and marked C. The filtrate was not further examined.

* Appendix to Pharmacopœia of India.
† Ibid.
‡ "Indian Annals of Medical Science," iv., p. 104.

* "Pharm. Journ.," June 14, 1873.
† "Pharmacographia."
‡ Gmelin's "Handbook of Chemistry," vol. xvii., p. 94.
§ "Commercial Organic Analysis."



COMPOUND GOODS TANK LOCOMOTIVE, NORTH EASTERN RAILWAY.

MR. T. W. WORSDELL, M. INST., C.E., ENGINEER.

Examination of Ether Solution A.—The solution was agitated with dilute hydrochloric acid, to remove any principles of an alkaloidal nature. The ether was then separated and evaporated; the resulting extract was pale amber in color, viscid at first, very bitter, and had a marked odor of the oil. It contained sulphur. It was easily soluble in 60 per cent. alcohol, ether, chloroform, etc., but insoluble in acids or in caustic alkaline solutions. It had the properties of a neutral resin.

The hydrochloric acid solution was of a yellow color; it was mixed with ammonia, which occasioned a white precipitate, and agitated with ether. The ethereal solution on evaporation left a yellow residue, not readily soluble in dilute acids. The dilute sulphuric acid solution was bitter, and yielded a precipitate with alkaline carbonates and hydrates, phosphomolybdic and picric acids, potassio-mercuric iodide, chloride of gold, and perchloride of platinum. This principle had therefore the properties of an alkaloid.

Ether Solution B.—On evaporating the ether solution B, a dark reddish bitter extract was obtained, soluble in alkaline solutions, and reprecipitated in yellowish flocks by dilute acids. It had the properties of an acid resin.

Precipitate C.—The precipitate was well washed, and dissolved in alcohol; on evaporation a brittle, darkish residue was obtained, soluble in alkaline solutions, reprecipitated in yellowish flocks by acids, soluble with very great difficulty in ether, easily soluble in chloroform. This principle thus also had the properties of an acid resin.

In addition to the principles above described as being present in the oil, an examination of the cake left after expression of the oil indicated the presence of another neutral principle, insoluble in ether or alkaline solutions, but dissolving in chloroform.

COMPOUND TANK ENGINE, NORTHEASTERN RAILWAY.

WE give an external elevation of a new type of mineral tank engine—Worsdell & Von Borries' system—in use on the Northeastern Railway, England, for which we are indebted to the *Engineer*. In another impression we shall give details of this engine, designed by Mr. Worsdell. These engines are used for working heavy mineral trains from the Durham and Newcastle coal fields to their destination, east and west. The usual weight of the train on the average gradient is forty loaded wagons, carrying ten tons each, or sixteen tons, inclusive of the weight of the wagon, or a gross weight of 640 tons. The design of these engines is precisely the same as that of the six-wheeled coupled compound goods engine in regular use on the Northeastern Railway, the only difference being that these have side tanks on a longer frame to carry the coal bunker and part of the water tank, and a pair of trailing wheels with radial axle boxes, which gives a considerable range to enable the engines to enter sharp curves of sidings and colliery lines in the districts where they have to work. The consumption of coal has been found to be approximately the same as all the other compound engines, viz., from 15 to 20 per cent. saving over non-compound engines working the same traffic. The principal dimensions of these fine engines are as follows:

COMPOUND MINERAL TANK ENGINE.

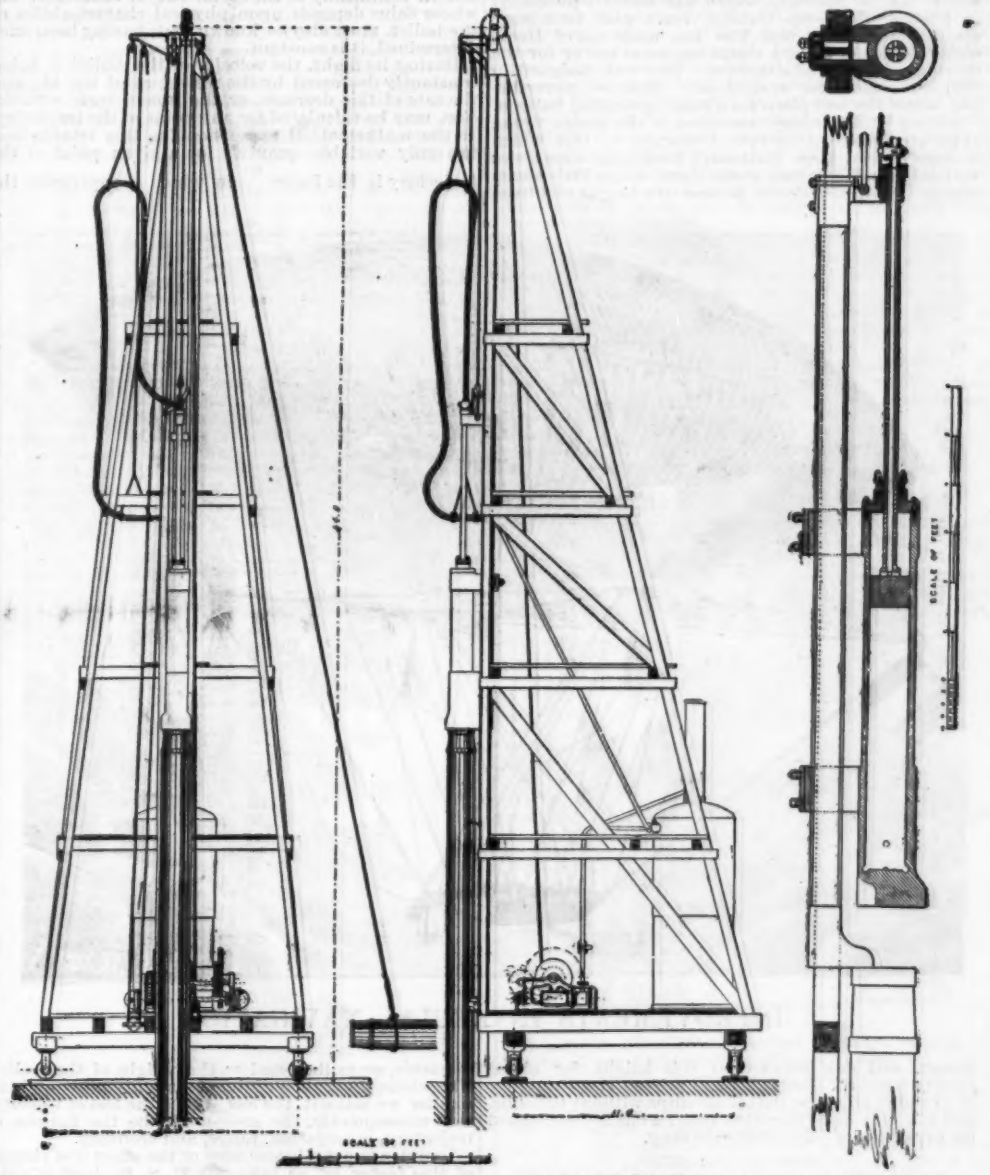
	ft.	in.
Cylinder (high-pressure):		
Diameter of cylinder	1	6
Stroke of piston	2	0
Length of ports	0	11⅝
Width of steam ports	0	1¾
Width of exhaust ports	0	3½
Distance, center line of cylinder to valve face	1	1
Trick valve:		
Lap of slide valve	0	1⅛
Maximum travel of valve	0	5½
Inside clearance of valve	0	0⅛
Lead of valve	0	0 1/16
Distance apart of cylinders, center to center	2	0
Distance apart of slide spindles, center center	2	0
Cylinder (low pressure):		
Diameter of cylinder	2	2
Stroke of piston	2	0
Length of ports	1	5
Width of steam ports	0	2
Width of exhaust ports	0	3½
Center line of cylinder to valve face	1	5
Lap of slide valve	0	1⅛
Maximum travel of valve	0	5⅛
Lead of slide valve	0	0 1/16
Inside clearance of valve	0	0⅛
Motion (Joy's system):		
Diameter of piston rods	0	3
Length of slide block	1	2
Length of connecting rod between centers	6	5¾
Wheels (cast steel):		
Diameter on tread, coupled wheels	5	1¼
Diameter on tread, trailing wheels	3	9¼
Throw of crank pin for coupling rods	0	11
Diameter of crank pin, driving wheels	0	3¾
Diameter of crank pin, leading and intermediate	0	3⅛
Length of crank pin	0	4 1/16
Thickness of tires on tread	0	3
Width of tires	0	5⅛
Crank axle (steel):		
Diameter at wheel seat	0	8⅛
Diameter at bearings	0	7
Diameter at center	0	6¾
Distance between centers of bearings	3	10
Length of wheel seat	0	7⅜
Length of bearing	0	9
Diameter of crank bearings	0	7⅛
Length of crank bearings	0	4½
Distance between centers of cranks	2	0
Leading and intermediate axle (steel):		
Diameter at wheel seats	0	8⅛
Diameter at bearings	0	7
Diameter at center	0	6¼
Length of wheel seat	0	7⅜
Length of bearing	0	9
Distance between centers of bearings	8	10
Trailing axle (radial box):		
Diameter at wheel seat	0	8
Diameter at bearings	0	6⅛
Diameter at center	0	6
Length of wheel seat	0	6⅜
Length of bearing	0	11
Distance between centers of bearings	3	8
Frames (steel):		
From center of leading wheels to front buffer beam	5	3
From center of leading to center of driving wheels	8	0
From center of leading to center of intermediate wheel	8	6
From center of intermediate to center of radial wheels	6	0
From center of radial axle to back end of frame	4	6
Distance apart of frames	4	0
Thickness of frames	0	1

	ft.	in.
Boiler (steel):		
Height of center to rail	7	5½
Length of barrel	10	7
Diameter of barrel, outside	4	3
Thickness of plates	0	0½
Thickness of smoke box tube plates	0	0⅝
Pitch of rivets	0	1⅞
Diameter of rivets	0	0⅞
Fire box shell (steel):		
Length outside	6	0
Breadth outside, at bottom	3	11
Depth below center line of boiler	5	0
Thickness of throat plate	0	0⅝
Thickness of sides and top plate	0	0⅜
Thickness of back plate	0	0 1/16
Pitch of copper stays	0	4
Diameter of copper stays	0	1
Roof stays (cast steel girder section)	—	
Inside fire box (copper):		
Length at bottom, inside	5	3⅝
Breadth at bottom, inside	3	3
Top of box to inside of shell	1	3½
Depth of box, inside	5	9½
Tubes (brass):		
Number of tubes		208
Length between tube plates	10	11⅛
Diameter, outside	0	1¾
Thickness, No. 11 and No. 13 B. W. G.	—	
Height of chimney from rail	13	1

Heating surface of tubes	1026·12 sq. ft.		
Heating surface of fire box	110	"	
Total	1136·12	"	
Grate area	1·23	"	
Working pressure	160 lb.		
Tanks:			
Capacity for water	1300 gals.		
Capacity for coal	2 tons.		
Weight of engine (empty):	Tons.	cwt.	qrs.
Leading wheels	14	5	2
Driving wheels	12	3	3
Intermediate wheels	11	3	0
Trailing wheels, radial	6	6	0
Total	43	18	1
Weight of engine (full):			
Leading wheels	14	19	3
Driving wheels	14	17	0
Intermediate wheels	15	11	0
Trailing wheels (radial)	8	14	2
Total	54	3	0

IMPROVED STEAM PILE DRIVER.

DIRECT acting steam pile drivers have now come into very general use for all works where time is an important element. The pile driver illustrated herewith is an improvement on steam pile drivers hitherto in ordinary use, in which the piston rod and "monkey" are in one, and which of necessity have a stuffing box at the bottom of the cylinder. In the machine shown the cylinder and monkey are in one casting, and form the movable part giving the blow to the pile, while the piston rod remains stationary in relation to the pile. The bottom of the monkey being solid, there is no dripping of water from condensed steam on to the pile head. Another advantage in the De Wit pile driver is that the steam hose or pipe which conveys steam from the boiler to the pile driver remains stationary during working; consequently there is but little wear and tear. In the pile driver under notice the piston rod is fixed to an H iron frame, provided at its lower part with a foot, which rests upon and guides the head of the pile. A recess is cast in the monkey, as shown, to give room for this foot. As the pile descends, the frame, piston rod, and piston descend with it. Steam is admitted into the cylinder or monkey through the hollow piston rod and transverse holes immediately above the piston. Both piston and rod are in one forging. The admission and exhaust of steam is controlled by a three-way cock, worked by hand from a rope attached to a handle. The handle could be worked automatically, but this is not considered desirable. The machine is single acting, the cylinder and monkey being lifted by steam pressure, and falling free when the exhaust is opened. The



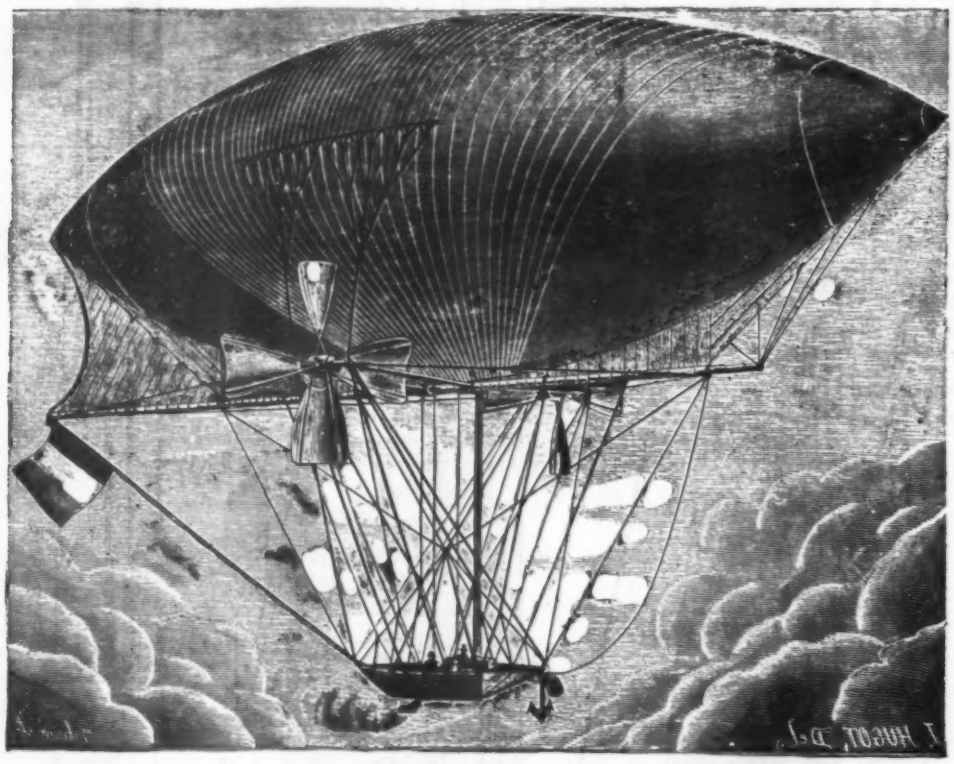
IMPROVED STEAM PILE DRIVER.

pile driver, controlled by hand, is capable of making from thirty to thirty-three strokes per minute, and of driving from twenty to twenty-five piles per day, according to the nature of the ground. It is being introduced by Mr. A. E. W. Gwyn, of 9 Ducksfoot Lane, Cannon Street, E. C., who is the sole agent for Great Britain and the Colonies. Various sizes are made, the smallest having a monkey of 6 cwt. and the largest one of 30 cwt., the latter being the machine shown in our illustrations. The stroke of this machine is 6 ft. 5 in., and the diameter of cylinder 9¼ in. The machine is constructed to drive piles up to 30 ft. 4 in. long. The framework is of timber, mounted upon four wheels. The boiler is of the vertical type, 10 ft. 6 in. high by 4 ft. 3 in. diam., and the steam winch is supplied with two distinct motions, one for lifting the pile into position and the other for raising the monkey. The total weight of the pile driver is 7¼ tons, and there are 175 cub. ft. of timber in the staging. We are informed that these pile drivers have done good work at Antwerp, Bremen, and Amsterdam. They have also been used on the North Eastern Railway, and are being employed in the construction of the Manchester Ship Canal.—*Industries.*

IMPROVEMENTS IN AERIAL NAVIGATION.

WE give herewith an illustration from Henri de Graffigny's work on "Aerial Navigation and Balloons which can be Steered," which was recently published in France. It shows Gabriel Yon's plan for a large steam balloon. In this Yon has made use of Henri Giffard's idea of using a steam engine as motor for the driving apparatus of a balloon. This was designed in 1880, but was never worked out. It shows, nevertheless, one of the best plans for a steam-propelled balloon.

Among other things described is the steam flying apparatus invented by Prof. Forlanini in 1878, which consists of two large stationary horizontal wings, two vertical propeller wings above them, and a little steam engine. With this device he rose to a height of fifteen



IMPROVEMENTS IN AERIAL NAVIGATION.

meters, and flew forward at this height for about twenty seconds. Forlanini has proved the feasibility of dynamic air ships, that is air ships without balloons, and it is only to be regretted that he has not continued his experiments.—*Illustrirte Zeitung.*

REDUCTION OF CALIBER IN MILITARY RIFLES.

THE past ten years have witnessed a constantly increasing activity in the attempts of military scientists to increase the power and efficiency of military weapons.

Since the finally decisive results of a battle generally depend upon infantry fire, and since the cost of constructing and experimenting with an infantry rifle is so small as compared to the money expended upon a modern, high-power cannon, it seems natural, at first sight, to expect a corresponding relation between the efforts made to develop the two weapons.

Such, however, has not been the case. The cost of infantry armament, considered collectively, is very great. The adoption of a new model involves a partial, if not a total, loss of the thousands of dollars invested in arms of the older type, and, in addition to this, there is ever present the feeling of uncertainty as to when a similar sacrifice may be again rendered necessary.

These reasons have caused nations to be very cautious in dealing with the subject of infantry armament. Most of them are extremely conservative, and have made changes only after some more enterprising power had taken the lead, and, by adopting a superior weapon, had caused the others, through self-defense, to follow its example. This long-protracted neglect has been terminated during the past few years by a universal stirring up of the military world and a concentration of its attention upon the subject of reducing the caliber of the military rifle.

Ten years ago the calibers of the adopted weapons of this class were to be found between 0·423″ and 0·45″. About that time Sweden introduced into her service the Jarmann, caliber 0·397″, and, for general purposes, this rifle soon proved its superiority. About 1882, Prof. Hebler brought out in Germany a rifle of 0·296″ caliber, as finally adopted, and with it he obtained results far superior to those of the systems in general use. Since the advent of this gun there has been a general rush toward small calibers, and England, Germany, France, Italy, Austria, and Portugal have adopted or are about to adopt calibers varying but little from 0·31″.

One can scarcely pick up a periodical, military or otherwise, without seeing some mention of the small caliber rifles of Europe, and this seems to indicate that a popular discussion of the principles involved in this reduction would be of interest to the general public.

The efficiency of a military rifle is measured by the flatness of trajectory, accuracy of flight, and penetrative power of its bullet.

The science of "exterior ballistics" enables us to compute accurately the trajectory of a bullet, if we know its weight and diameter and the velocity with which it leaves the muzzle of the gun. The first two factors are, of course, easily determined, and the latter, given by electrical time-measuring instruments, may be taken as constant for similar bullets fired with equal charges from the same gun. Another factor, known technically as the coefficient of reduction, and whose value depends upon physical characteristics of the bullet, must also be known, but, having been once determined, it is constant.

During its flight, the velocity of the bullet is being constantly decreased by the resistance of the air, and the rate of this decrease, or the *atmospheric retardation*, may be calculated for any point of the trajectory. In the mathematical expression for this retardation, the only variable quantity for a given point of the trajectory is the factor $\frac{d^2}{w}$, in which d represents the diameter, or caliber, and w the weight of the bullet. The whole thing then centers upon this ratio, and the smaller we make it, the less will be the loss of velocity, and, consequently, the greater will be the flatness of trajectory, penetration, range, and accuracy.

In order to get a better idea of the effect of a change of this factor, let us take the U. S. Springfield rifle, and suppose its caliber reduced from 0·45″, its present value, to 0·30″, the initial velocity ($\bar{v}$) and weight of bullet remaining the same, and see what the effect would be upon the range corresponding to an elevation of 15°. We find by calculation, (1) that our service bullet would attain a range of about 2,429·9 yards, while the new one would travel nearly 1,300 yards further, attaining a range of about 3,613 yards; (2) that the new bullet would have, at this greater range, *a penetration about 3·4 times that of the service bullet at the lesser range;* (3) that the new value of factor $\frac{d^2}{w}$ would be 1·260, and that its present service value is 2·835. The change in this factor due to our supposed reduction of caliber has apparently produced this marvelous improvement in the trajectory.

Let us now consider the effect of changing the weight of the bullet. Every charge of powder has a certain amount of *work* stored up in it, and the percentage of this that we are enabled to utilize, by transferring it in the shape of *energy* to our bullet, depends upon the number of times the space occupied by the powder is contained in the cubic capacity of the bore, or the number of *volumes of expansion* allowed the gaseous products.

With the same charge and gun, then, we may with little error assume the initial energy of the bullet to be the same, no matter what the bullet's weight. The energy depends upon the weight and the velocity, and if it remains constant while the weight decreases, the velocity must correspondingly increase.

The Springfield rifle fires a bullet weighing 500 grains and gives it an initial velocity of 1,301 feet per second, which corresponds to an energy of 1,877·9 foot pounds. Now, if we suppose a bullet weighing only 225 grains (the weight of the Hebler bullet) to be substituted for the 500 grain one, it would have an initial velocity of 1,989 feet per second.

The above examples serve to illustrate the reasons generally given by the uninformed to explain the advantages of decreasing the caliber. They are: (1) that it decreases the factor $\frac{d^2}{w}$, and therefore increases the range; (2) that it permits the use of a lighter bullet and the attaining of a higher initial velocity.

While these statements are liable to appear sound and convincing to the popular mind, they are not founded upon truth and do not give the slightest idea of the real reason for the reduction of caliber. In the first example taken to show the effect of decreasing $\frac{d^2}{w}$, we supposed d to decrease while w and v remained the same. This latter supposition was false, and could be true only when there was a corresponding increase in the efficiency of the charge or motive force. In the second example, we said nothing of the effect upon $\frac{d^2}{w}$ produced by the decrease of w. In point of fact, this factor, and with it the resistance of the air, would be so much increased that the bullet would soon be compelled to part with its high velocity, and the resulting trajectory would be far inferior to that of the heavier bullet with the lower initial velocity.

Let us consider some of the evident difficulties that must be encountered in the reduction of caliber.

1. *Loss of Power.*—We cannot increase the length of our gun, on account of its limited weight, and, consequently, our new bore must have a capacity bearing to that of the former the increased ratio of the squares of the two calibers. The number of volumes of expansion allowed the gaseous products is correspondingly reduced, and, therefore, the work performed is less. This is made still more plain from another standpoint. To produce the same effect, we must have the same cause, or the mean pressure upon the bases of the two bullets (supposed of equal weights and different diameters) must be the same. To fulfill this condition, the pressure per unit of area upon the base of the smaller bullet must be greater than the corresponding pressure upon the base of the larger one, and in the direct ratio of the squares of their diameters. A still further increase of power would be necessary in order to perform the greater work of giving sufficient rotation to the smaller and longer bullet.

2. *Fouling and Leading of the Bore.*—These disadvantages would increase with the reduction of caliber, unless prevented by some change in the material of the bullet.

3. *Vibrations.*—Supposing the necessary increase of power attained, vibrations in the barrel would be greater on account of the largely increased pressures. To assume that these vibrations exist, and that they vary directly with the pressure, is the only reasonable way of accounting for certain observed anomalies.

Commander Folger, U. S. Navy, by boring out the chamber of a 0·50″ caliber Remington to fit a longer shell, obtained in a 450 grain bullet a velocity of over 2,000 feet per second, and yet, for accuracy at 500 yards, this rifle was inferior to what it was under the old service conditions. Unfortunately, his report does not show that he tried the effect of securing the barrel in such manner as to prevent or at least decrease the vibrations.

These are grave difficulties, and to counterbalance them, the advantages must indeed be great.

It is claimed that the new rifles give flatter trajectories and longer ranges, and an inspection of the accompanying table will show that these claims are well founded. We look to the ballistic data for an explanation of this, and—taking the Hebler rifle, for instance—we see that the departures from the old models, as represented by the Springfield, consist in the introduction of a bullet 4·4 calibers in length instead of 2·8 calibers, as in the Springfield, and the rapid twist of about one turn in four inches which is made necessary by the long bullet. By this change a value of 2·726 is obtained for the factor $\frac{d^2}{w}$ as compared to 2·835 in the Springfield. We also note the high initial velocity of 1,968 f. s. If the caliber of the Springfield were reduced to 0·296″—that of the Hebler—and our service cartridge used, the realized energy would be about 812·5 foot pounds, which is given by the proportion:

Service energy: new energy :: $0{\cdot}45^2 : 0{\cdot}296^2$.

This would correspond in the Hebler 225 grain bullet to a velocity of 1,276 f. s., and shows that Professor Hebler does more than decrease the retardation. *His motive force is 2·38 times that of the Springfield.* This is not due to the reduction in caliber, but to an improvement in his cartridge, either in its composition or its arrangement. The only difference in arrangement is that the charge is compressed and perforated. Our ordnance department has experimented with compressed and perforated charges without obtaining anything like the above increase of power. Since Professor Hebler does not claim to use any special powder, we can only conclude that our ordnance department did not carry its experiments as far as it might have done. The trajectory of the Pieri rifle, with which experiments are now being conducted in Italy, is superior to that of the Hebler, but the latter has been selected for comparison because our knowledge in regard to its details is more complete.

At first glance one is impressed with the idea that the exact effects of reduction of caliber should be susceptible of theoretical deduction, and that, if this be so, it is unwise to rush into the field of experiment like a blind man groping in the dark.

If the Hebler and Lebell guns get their results principally by improving the motive force, is it logical to contrast them with the older type of guns which have not the benefit of this improvement, and then ascribe the inferior trajectories of the older arms to their larger calibers? Most assuredly not, and yet this is what is universally done. If we suppose the motive force to be increased in our Springfield in the same ratio that obtains in the Hebler rifle, we should have a muzzle energy of 4,473·4 foot pounds instead of 1,877·9,

DESCRIPTIVE AND CALCULATED DATA FOR THE PRINCIPAL MODERN MILITARY RIFLES.

Rifle.	Country.	Cal.	$\frac{d^3}{w}$	Charge (grs.)	Bullet (grs.)	Cart'ge (grs.)	Length Bullet (cals.)	Twist (inches.)	Single Loader or Repeater.	Kind of Magazine. No. Cartridges.	Bolt or Block Mechanism.	Initial Velocity. (f. s.)	Muzzle energy per unit circum. (ft. pds.)	Remaining energy per unit circum. 1,000 yards. (ft. pds.)	Remaining energy per unit circum. 2,000 yards. (ft. pds.)
Hebler	.....	0·296	2·726	83	295	321	4·46	4·588	S. L.	.....	Bolt	1,968	3061·4	360·2	109·9
Lebell	France	0·315	1·709	*386	....	....	9	....	S. L. & R.	Tubular, 8	Bolt	2,034	3260·7	675·2	457·5
Freddi	Proposed for Italy.	0·315	3·087	83	225	256	3·57	....	S. L. mag. atch.	.....	Bolt	1,840	1358·1	225·8	85·8
Guedes-Kropatschek	Portugal	0·323	2·766	69·5	264	546	4·09	11·8	S. L. & R.	Box, 5	Bolt	1,673	1617·4	336·1	126·2
Pieri	Experimental	0·323	2·572	83	284	....	4·3	12·1	.....	.....	....	2,087	3927·7	460·5	150·6
Jarmann	Sweden	0·397	3·274	77	337	420	2·75	21·6	S. L. & R.	Tubular, 8	Bolt	1,526	1415·8	262·0	80·3
Vitali Vetterli '70-87.	Italy	0·414	3·845	62	312	408	2·34	20·28	S. L. & R.	Box, 4	Bolt	1,430	1089·6	184·0	46·0
Vetterli	Switzerland	0·414	3·845	55	312	465	2·34	20·28	S. L. & R.	Tubular, 11	Bolt	1,427	1084·9	183·7	45·8
Berdan	Russia	0·42	3·527	77	370	410	2·65	21·65	S. L.	.....	Bolt	1,444	1256·7	220·7	79·7
Mauser	Germany	0·433	3·4	77	366	603	2·42	21·66	S. L. & R.	Tubular, 8	Bolt	1,571	1554·0	275·7	89·0
Kropatschek	French Navy	0·433	3·4	81	386	676	2·42	21·66	S. L. & R.	Tubular, 7	Bolt	1,480	1288·7	254·9	76·6
Manlicher 1885	Austria	0·433	3·538	77	371	606	2·33	21·6	R.	Box, 5	Bolt	1,575	1501·2	252·8	72·3
Gras 1874-80	France	0·432	3·4	80	386	676	2·42	21·66	S. L.	.....	Bolt	1,480	1288·7	254·9	76·6
Remington 1871	Spain	0·433	3·4	77	386	634	2·42	25·50	S. L.	....	Block	1,340	1131·5	241·0	72·7
Martini-Henry	England	0·45	2·953	85	480	706	2·69	20	S. L.	.....	Block	1,315	1302·8	333·3	117·9
Springfield	United States	0·45	2·885	70	500	708	2·8	22	S. L.	.....	Block	1,301	1329·6	360·0	131·7

*The data upon which the calculations for the Lebell rifle were made were the best obtainable, but cannot be considered thoroughly reliable.

and an initial velocity of 2,007·9 *f. s.* instead of 1,301; and if we were then to change the bullet from one 2·8 to one 4·4 calibers in length, to correspond to the Hebler, our initial velocity would fall to 1,587 *f. s.*, but our value for $\frac{d^3}{w}$ would also fall, and as low as 1·804, which would compare very favorably with the Hebler value of 2·726. This change in $\frac{d^3}{w}$ would give the new bullet a greater range, in spite of its loss in initial velocity.

Another striking fact is that, if we assume 4·5 calibers as the length of the bullet, we find the value of $\frac{d^3}{w}$ for a caliber of 0·35″ to be 2·268, and for a caliber of 0·30″, 2·648. This seems to indicate that for a bullet of a given number of calibers in length, a *decrease* of caliber causes an *increase* in retardation. Let us investigate this subject a little more in detail.

Assuming the bullet to be cylindrical in shape, the following equation holds for the Springfield service bullet, which is 1·26 inches in length and weighs 500 grains.

$$(1)\qquad \frac{l \times \pi\, d^3 \times \text{weight 1 cu. in. lead}}{4} = 500.$$

And for any other bullet of the same material and shape we should have, representing its length in inches by l, its diameter in inches by d, and its weight in grains by w,

$$(2)\qquad \frac{l \times \pi\, d^3 \times \text{weight 1 cu. in. lead}}{4} = w.$$

Dividing (2) by (1), solving with respect to $\frac{d^3}{w}$, and multiplying both numbers by 7,000 in order to express the weight in pounds, we have

$$(3)\qquad \frac{d^3}{w} = \frac{1{\cdot}26 \times 0{\cdot}45^3 \times 7{,}000}{500\, l} = \frac{(0{\cdot}5529235)}{l}$$

Substituting for l, $x\,d$, x being the length of the bullet in calibers, equation (3) becomes

$$(4)\qquad \frac{d^3}{w} = \frac{(0{\cdot}5529235)}{x\,d}$$

which shows that, for any value of d, the retardation decreases with an increase of the length of the bullet in calibers. The limit to the increase of x is found in the difficulty in giving rotation, and must be determined for any given motive force by experiment. According to the standard of the latest and most advanced experience, 4·5 is about the maximum value that can be given to x when gunpowder is used as the motive force. Making this substitution and reducing, equation (4) becomes

$$(5)\qquad \frac{d^3}{w} = \frac{(1{\cdot}8997110)}{d}$$

Regarding $\frac{d^3}{w}$ and d as the two variables, we recognize this as the equation of an equilateral hyperbola. The three curves shown by corresponding diagram correspond to values of x of 9, 4·5, and 2·8, respectively. The ordinates are the values of $\frac{d^3}{w}$, and the abscissas of d, and from the rapid increase of the former in the ascending branch for small decrements in the latter, *it will be seen that each reduction of caliber will be at the expense of a great sacrifice of power.* The dotted lines parallel to the axis of $\frac{d^3}{w}$ are drawn to show the relative sacrifice of power produced under the different suppositions, by a reduction of caliber from 0·45″ to 0·30″. It will be noticed that the longer the bullet in calibers, the smaller this sacrifice becomes.

When our motive force enables us to increase the length of our bullet, the obvious effect is to lower the retardation for equal calibers.

Since all these disadvantages must be the results of a reduction of caliber, why is it ever advisable to reduce it?

The rifle is a machine for doing work, and the *work* performed by the charge in giving a motion of translation to the bullet must be equal to the *work* performed by the man in overcoming the *recoil* of the gun. Now, work is the product of two factors, a force multiplied into a path.

When a soldier fires his rifle from the shoulder, the *path* is quite limited, and, since the amount of work is constant for a given charge bullet and barrel, the force must be comparatively great. It all hinges, then, upon the capacity of the man to take up the recoil. His limit in this respect constitutes the limit of muzzle energy of the bullet, and from this we can easily pass to the requisite caliber. The point to be insisted upon is that the *caliber should always be as large as possible and the bullet as long as possible.*

The old way of reducing recoil was to keep the caliber the same and reduce the charge or motive force. The present method is to keep the motive force as great as possible and decrease the muzzle energy and the recoil by reducing the caliber. This produces the necessary decrease with the minimum sacrifice of flatness of trajectory and with the maximum increase of penetrating power. Every improvement, then, in the appliances for assisting the soldier to bear the recoil has the effect of *increasing*, and every improvement in the powder, or motive force, has the effect of *decreasing* the caliber of the theoretical gun.

The *expedient* of reducing the caliber in order to utilize an improved motive force should not be resorted to until exhaustive attempts have been made to increase our capacity for recoil work. After the limit of muzzle energy is fixed, there are several variables still to be determined, the principal one being the weight of bullet. The number of rounds of ammunition that the soldier is to carry, considered in connection with magazine guns, the relative value placed upon long and short range fire, and the limit to the increase of our motive force, are the three main points for consideration in fixing the weight of bullet. By substituting the selected value of w w, equation (5), we obtain the best corresponding caliber.

To recapitulate, then, it may be said:

1. That European nations have made great improvements in their small arm cartridges, and, through a better control over the rate of combustion of their powders, have obtained a more efficient motive force.

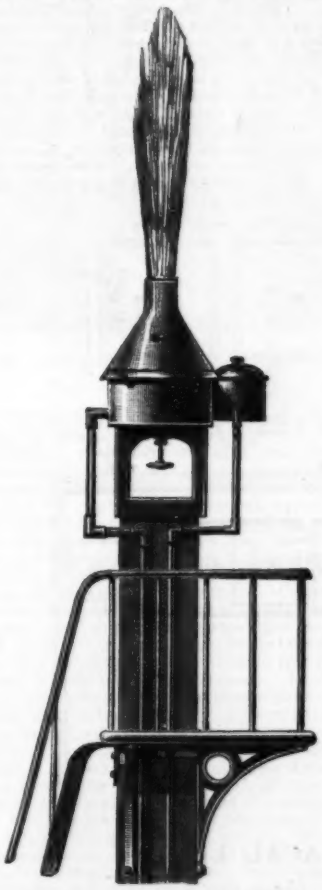
2. In consequence of these improvements, they obtain an increase of muzzle energy, and this necessitates an increase of recoil.

3. There are two methods of meeting the difficulty of recoil: (1) to increase the soldier's capacity to overcome it by means of springs and buffers, thus retaining *all* the advantages of the increased motive force, and (2) to *reduce the amount of the recoil by reducing the caliber, thus sacrificing part of the rifle's power.*

B. W. DUNN, 2d Lt. 3d Artillery, U. S. Army.

THE JUPITER LIGHT.

THE accompanying engraving illustrates a new "industrial" light now being introduced by the Harden



THE JUPITER LIGHT.

Star, Lewis & Sinclair Company, Cannon Street, London. It is intended to answer the same purpose as the well known Lucigen.

The principal feature of the Jupiter lamp is the mode of vaporizing the oil and preventing its escape in the form of spray, at the same time producing complete combustion, and giving a powerful and brilliant light. The lamp is lighted and controlled in the following manner: A small quantity of spirit is poured on the surface of the heavy oil contained in the well of the lamp. This well is connected with the tank or reservoir of oil, which gives an uninterrupted supply; a light is then applied and the radiating covers put on. The compressed air is then turned on, which, passing by means of a small jet through the center of the flame and over the surface of the oil in the well, assumes a high temperature, and also produces an induced current, which raises the gas of the heated oil, and at the same time draws in the necessary supply of air to complete perfect combustion and produce a brilliant light.

It is claimed that this invention completely overcomes the defects of other systems, for the reason that, as there is complete combustion, no oil can possibly pass away in the form of spray, which in practice has been found to be a very serious matter, as oil spray has in a gale of wind been known to be carried many hundreds of yards, and damaging all property that came within its reach.

The power required to work the Jupiter consists of a compressor and receiver, 2 H. P. being sufficient to provide compressed air for lights equal to 10,000 candle power. The oil used for giving this brilliant light consists of common creosote oil, crude petroleum, or any other heavy hydrocarbons, which can be purchased at a very low price.

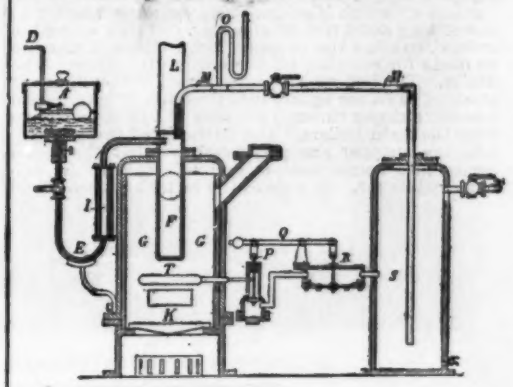
The photometric power of the Jupiter varies as required from 100 candle power to 2,500 candle power. The consumption of oil ranges from half to two gallons per hour.—*The Engineer.*

GAS FROM LIQUID FUEL.

By C. BROTHERHOOD, of Redland, Bristol.

THIS invention consists in apparatus constructed and arranged for the production, in an automatic manner, of gas from oil and other liquid fuel.

The oil for conversion into gas is supplied from a reservoir, A, situated at such a height as to afford a suitable head for the flow therefrom of oil to the retort,



and also to afford the required pressure of gas, by means of an adjustable stuffing-box and set screw below it. Or the cistern may be fixed, and a ball-cock employed governing the flow of oil through the pipe, D. By the siphon, E, the reservoir communicates with the retort, F, contained within the heating chamber, G. The pipe is fitted with a cock and with a "sight-feed" appliance, I, for observing the flow of oil to the retort. The heating of the retort is effected either by combustion of solid fuel placed on the fire bars, K, or by gaseous fuel in combustion supplied to a perforated burner, T; but when solid fuel is employed, the burner is withdrawn. The products of combustion escape preferably by two chimneys, L, situated at the opposite side of G. The gas generated in the retort passes out through the outlet pipe, M, by which it is conducted (either directly or through a receiver or collector) to the point of consumption. The pipe, M, is fitted with a safety valve, O, consisting merely of a siphon tube containing mercury. If, while the stopcock of the outlet pipe is closed, oil be admitted to the retort and subjected therein to the action of the fire, the pressure of the gas generated will, in due time, reach a point at which the column of oil is balanced, and the flow of oil to the retort thereby suspended; but on opening the cock, the gas escapes, and the equilibrium, of course, is destroyed. The oil then resumes its flow to the retort, and the production of gas is continued. Toward the lower end of the spindle, P, is a valve having an orifice extending through it. The spindle is connected at the upper end to the lever, Q, toward one end thereof. At that end of the lever is a balance weight; while at the other end it is connected to the spindle, R, extended into a chamber, and attached at the lower end to a flexible gas-tight web or diaphragm secured to the under side of the chamber. The chamber communicates with the receiver, S, to which gas is supplied by the pipe, M. As the pressure in the chamber, R, varies with the demand made upon the gas, the web or diaphragm is acted upon accordingly; and the valve is opened or

closed through the medium of the counterweighted lever, Q, the arrangement being such that a reduction in pressure in the diaphragm chamber causes a corresponding opening of the valve in P, and affords an increased supply of gas to the burner.

THE TREATMENT OF AMMONIACAL LIQUOR.

THE treatment of that by-product of tar distillation, ammoniacal liquor, has always involved many practical difficulties, which have been enhanced by the provisions of the alkali act prohibiting the escape into the atmosphere of gaseous combinations offensive to the public. At the Wear Patent Fuel Works, Sunderland,

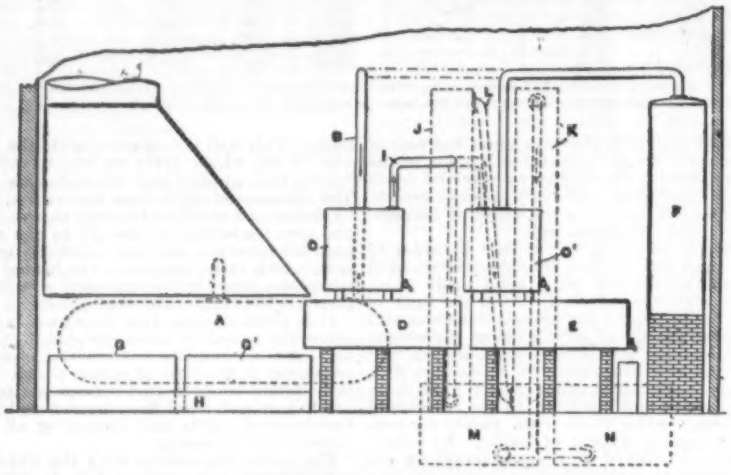


FIG. 1.—FRONT ELEVATION.

various minor improvements have been made in the mode of treating the ammoniacal liquor for the purpose of extracting sulphate of ammonia, and since the beginning of last March a new method of dealing with the waste gases has been introduced. Through the courtesy of Mr. William Dixon, general manager of the Wear Patent Fuel Works, South Docks, Sunderland, and of the Redheugh Tar Product Works, Gateshead-on-Tyne, we are able to illustrate and describe this new process.

Prior to the date above mentioned, the "column" system was in vogue at the Wear Patent Fuel Works, and the plant is still retained, being made use of when the plant for the improved process is being repaired. The accompanying illustrations show in Fig. 1 an elevation and in Fig. 2 a plan of the complete plant. The first process through which the ammoniacal liquor passes is that of being boiled. This is effected in the "stripper," which is an egg-ended cylindrical boiler, A, 25 feet long and 6 feet in diameter, elevated above the ground, to allow the necessary connections of pipes to be made for carrying off the sedimental refuse to the drains. The boiling process is carried out by means of steam of 60 lb. per square inch pressure, which is passed into the stripper through a system of 2 in. copper pipes from the main boilers. The portions of the pipes inside the stripper are perforated, so that the steam comes into actual contact and mixes with the ammoniacal liquor. As soon as the latter has been raised to boiling point, the supply of steam through the perforated tubes is cut off, and the boiling is continued by means of steam passing through a coil of pipes which is also located inside the stripper. The vapors from the ammoniacal liquor, which commence to evolve at a temperature of about 190° F., pass out of stripper through metal pipes, B, to the saturators, C, situated in an adjoining building, where they are neutralized in the ordinary manner by means of sulphuric acid. As soon as the process of neutralization is completed the fluid is passed into the settlers, D or D¹, situated conveniently below the saturators; settlers, D and D¹, being in connection with the saturator, C, while the remaining settlers, E and E¹, and the saturator, C¹, form an independent arrangement in connection with the column, F. In case of need, however, both sets of saturators and settlers can be used for either the old or the improved process. After the settling process is completed, which usually takes about an hour, the clear liquor is passed into the evaporators, G and G¹, which are of the ordinary type, having in close conjunction drainers, H, on which the sulphate of ammonia deposited in the evaporators is afterward placed. Returning to the stripping process, the lime is introduced into the boiling ammoniacal liquor, as in the ordinary column process, in order to free the fixed ammonia, and one of the advantages of this improved method is that it facilitates the liming process, which is effected by injecting the lime by water pressure into the top of the stripper. Besides other minor advantages as compared with the column system, Mr. Dixon's improved arrangement obviates the necessity of heating the ammoniacal liquor prior to introducing it into the stripper. There is also a considerable saving of time, as the entire operation of treating 3,000 gallons of ammoniacal liquor is effected in the new plant in from eight to eighteen hours, according to the strength of the liquor, while in the old system ten to twenty hours were occupied in completing the process.

The disposal of the waste gases is also carried out by an improved method. The sulphureted hydrogen which accumulates in the saturators passes through suitable pipes, I, to the condensers, J and K. Previously these gases were discharged underneath the gates of the furnaces of the main boilers. This practice, however, had to be abandoned under the provisions of the alkali act. The gases are now conducted into the condensers, J and K, which are two flat-ended cylinders 12 feet high and 3 feet in diameter. They are connected together by a cast iron pipe, L, 8 in. in diameter, and placed at an angle so as to connect the bottom of the condenser, K, to the top of the condenser, J, as shown in Fig. 1. The gases enter J, and are therein partially condensed by the atmosphere and by a spray of water. After passing through the condenser, K, all the moisture in the gases is removed. The gases then pass through a 6 in. pipe into one of the two purifiers, M and N. Each of the condensers is provided with traps formed of 2 in. pipes for passing the retained moisture and the water used in condensing to the sewers. The purifiers shown are built of bricks, and are 7 feet square and 6 feet deep. Some distance above them is erected a substantial shed roof, O, to protect the oxide of iron with which the purifiers are filled from the weather. As already indicated, the gases from the condensers pass into the bottom of one of the purifiers, although two are provided, so that in case one becomes fully charged, the other is available while the sulphureted oxide of iron is removed and the purifier recharged.—*Industries.*

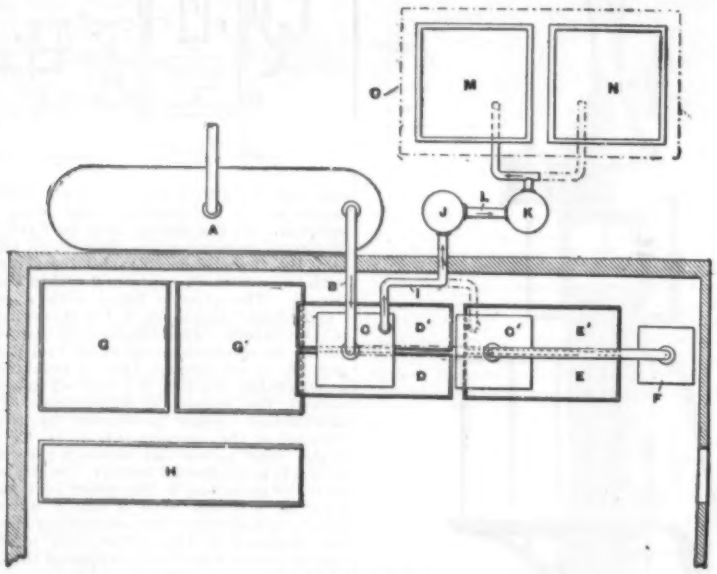


FIG. 2.—PLAN.

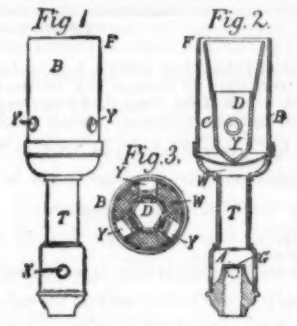
TREATMENT OF AMMONIACAL LIQUOR.

BUNSEN GAS BURNERS.

By C. AUER VON WELSBACH, of Vienna.

THIS invention relates to the construction of a Bunsen burner in such a manner as to produce a circular flame with internal as well as external air supply.

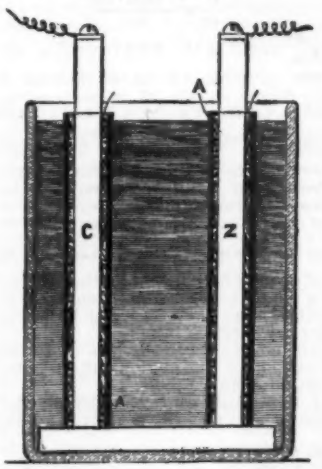
The gas, entering at the bottom, passes vertically through several small holes in a thin plate, G, into a cavity, A, into which air enters through lateral apertures, X. From the cavity the gas and air ascend a tube, T, which expands at its upper end to a diameter equal to that of the desired flame. The expansion is covered by wire gauze, W, which serves to mix the gas and air, and distribute the mixture uniformly through the enlarged part, B, of the tube. The mixture then ascends an annular passage, C, formed between the external tube, B, and an internal tube or thimble, D, which is closed at its lower end, and tapers to a larger diameter at its upper end. To the lower part of the thimble there lead several inlets, Y, for air from outside the outer tube, B; these inlets being formed by short tubes crossing the annular passage, C. At F (the upper end of the tubes) the mixture of gas and air issues from the annular mouth between them; and this mixture, being ignited, forms a circular flame, which receives air not only from the outside, but also from the interior of the thimble, D, to which the air is admitted by the inlets, Y. The upper part of the tube, B, and of the thimble, D, may be of metal, as shown. It is generally, however, preferable (says the author) to make the parts which are next the flame of steatite or such like material.



FAURE'S NEW SECONDARY BATTERY.

IN a patent recently issued to M. Camille A. Faure, the inventor describes a form of cell embodying several novel points. In the new battery, M. Faure employs two elements widely separated in the electromotive scale. They are composed of finely divided particles pressed together in a self-supporting mass or body, or composed of plates of metals having combined therewith finely divided and compressed particles of the same metal. Each element is inclosed by a diaphragm or septum of prepared asbestos, which consists of sheets one thirty-second of an inch thick, dipped into a solution of soluble salt, such as the chloride of calcium or the chloride of barium. The sheet is then dried, after which it is dipped into a solution of a soluble silicate, such as the silicate of soda or a fluosilicate, which are capable of producing, with the first named substance, an insoluble compound.

The elements so prepared are placed in a cell containing an electrolytic solution, which must be of such a nature that in the process of electrolysis it forms an insoluble compound with the metal or metals composing either or both elements. Thus M. Faure takes zinc and copper, and combines with the zinc finely divided zinc and with the copper finely divided copper. The electrolytic solution preferably employed contains the phosphate of potash.



The accompanying cut (reproduced from the *Electrical World*) shows the cell diagrammatically. C and Z are copper and zinc plates, having combined with them the same respective metals in a finely divided compressed state. These are wrapped with asbestos, A, prepared in the manner described above, and immersed in the proper solution containing phosphate of potash.

On subjecting such a cell to the action of an electric current, phosphate of copper is formed upon the surface of the copper element, the phosphoric acid for this purpose being electrolytically separated from the solution, and combines with the copper to form an insoluble compound—*i. e.*, the phosphate of copper. M. Faure then substitutes a fresh solution of phosphate of potash for the exhausted solution, and upon connecting the battery in a simple circuit for the purpose of discharge, phosphoric acid is transferred from the solution to the zinc, and from the copper to the solution, so that the solution remains unchanged as regards its constituent elements. Of course this preliminary

preparation would be avoided if phosphate of copper were placed upon the copper element in the first instance; but phosphate of copper is not easily obtained and manipulated, and the process described is said to accomplish the object desired.—*Electrical Review.*

PRACTICAL HINTS ON WATER COLOR PORTRAIT PAINTING OVER PHOTOGRAPHIC ENLARGEMENTS.

By E. W. CURRIER.

HAVING secured a solar print (egg shell paper), the first work is to touch out all white spots or imperfections in the face, which is done with a pigment composed of India ink, Indian red, and neutral tint mixed together on the palette to match the tone of your print.

This done, the flesh wash is flowed over the face. This wash is composed of scarlet vermilion with a large quantity of water, mixed in a water color slant. Use a No. 10 red sable brush and work across the face, beginning at the top of forehead and working the color down evenly. Having now applied this tint evenly over the entire face, let it get thoroughly dry before working in the shadows.

Directions for painting the hair: For brown hair use sepia toned down with lamp black, if dark brown; if reddish brown or auburn cast, add a little burnt sienna to your sepia. For black hair use lamp black, with ivory black for the strong shadows. Blond hair may be made with Roman ocher, or yellow ocher and Chinese white, according to the tint. Always use great care in painting the hair, avoid getting a wiry or ropy appearance, always soften the edges of hair with a wet brush, especially next the forehead. For the darkest shadows over the eyes, the nostrils, and shadow between the lips, use brown madder, with the edges softened with Rubens madder. Rose madder is used for painting the under lip, and cobalt blue should be stippled in around the edges of the lips, also in the half tints between hair and forehead and around eyebrows.

Rose madder should be hatched in the center of cheeks in a delicate tint.

In painting the eyes, be careful not to have the catch light too large, as this light seems to enlarge out of proportion by photography; also preserve the shape and location of this catch light, as this gives the expression to the eyes. For blue eyes use Payne's gray. For brown eyes, sepia. For black eyes, ivory black with a touch of sepia. For hazel eyes use Payne's gray on the outside of the iris and burnt sienna next to the pupil. For the white of eyes use Chinese white lowered with cobalt and a slight touch of lamp black, painting in a touch of pale vermilion in the corners of eyes nearest the nose.

Directions for working the drapery: For black drapery use lamp black, having first darkened the shadows with No. 3 Conte crayon with your chammois clump. Pulverized pumice stone mixed with powdered No. 3 black Conte crayon makes a very valuable preparation for working drapery of all kinds, also for shading the background. For dark backgrounds, where a dark stippled ground is desired, use sepia mixed in a thin wash with Prussian blue. After working the drapery, the face may again occupy our attention. The first wash we applied being now perfectly dry, stipple in the shadows with a tint composed of sepia and indigo blue with *brown madder* worked into the deeper shadows. Do not get your eyes too near your work while stippling, but sit with your arms at full length, as the uneven surface is much easier smoothed up when not too close to the picture. For navy blue suits or soldiers' coats use Prussian blue mixed with water of ammonia, as the ammonia makes the wash flow smoothly, for if not used it is almost impossible to put on the wash evenly, as Prussian blue is a poor color to use in washes. In painting white lace collars, trimming, etc., use Chinese white and neutral tint for first painting, and when dry paint in the pattern of the lace with pure Chinese white. Use a little cobalt blue in thin washes in the shadows of the lace. For jewelry use gold bronze for first painting, and, when dry, shadows are painted in with sepia and the high lights with Chinese white and slight tint of Naples yellow added to the white. The following list of colors are necessary: Reynolds' Chinese white, ivory black, lamp black, Prussian blue, India blue, French blue, cobalt blue, Payne's gray, scarlet lake, scarlet vermilion, rose madder, brown madder, Rubens madder, Indian red, Italian pink, Roman ocher, yellow ocher, Naples yellow, burnt sienna, burnt umber, raw umber, bister, sepia, neutral tint, emerald green, Indian yellow, carmine, Hooker's green, Vandyke brown.

A stick of No. 3 black Conte crayon, a chamois skin stump, 1 oz. pulverized pumice stone, 1 slant, tumbler, and the following numbers of long-handled red sable brushes, No. 4, 5, 6, 7, 10 and 12, and a large black sable brush for washers. I prefer one with a brush at each end. These materials are to be found at any artist's material store. To give relief to a head or figure, the background should be darkest back of the light side of head or figure and lighter next to the shadowed side of head. Be careful in stippling the face not to use the color very thick in the brush or very much color in your brush. Soften all the edges of the drapery and features, leaving no sharp lines. Rubens, the great artist, is reported to have said, "Paint your lights white; place next to that yellow, then red, using dark red as it passes into the shadow. Then with a brush dipped in cool gray pass gently over the whole till they are tempered and sweetened to the tone you wish." His remarks apply to painting in oil, but the principle is the same in water colors. Drawing is of infinite importance to the student of art, and we would suggest all spare time be occupied in drawing from Ducollet, "Elementary Studies of Features and Heads," which can be obtained of Janeutzky & Weber, 1125 Chestnut Street, Philadelphia; also Julien, "Etudes d'apres l'antique," coilection of the best antique studies from European museums, to be had at the same store. These should be copied with charcoal, using charcoal paper, and stale bread for removing too heavy shadow or where mistakes are made in the drawing. The drawings may be *fixed* after being finished by blowing the surface over with fixative, by means of the atomizer, kept at all artist's material stores. Observe when painting eyes in a portrait to paint in the catch light on the same side of the eye as the light falls on the face. We have often seen this mistake made among amateurs—the catch light painted in on the shadowed side of face, which is entirely wrong. As it is often convenient to understand something about landscape painting, as used in backgrounds of figure paintings, a few words in regard to the same would not be out of place. For skies, use cobalt blue and a little lamp black added. After this wash is dry the distance may be washed over with a thin solution of rose madder. For tree trunks, Vandyke brown or Payne's gray may be used. For the leaves, a green composed of Indian yellow and lamp black and burnt sienna. Never leave the foliage a decided green, but use burnt umber with the greens, which softens the tone. In autumn scenes, a wash of light red may be flowed entirely over the ground and sky; after getting dry it can be painted over in the usual manner. This wash tends to give a warm tone, not to be obtained by any other method. The shadows of a color always partake of their complementary color. This rule applies to all paintings where color is used, but the complementary color must not be used strong, only a very slight tint. For instance, green is the complementary color to red, hence a piece of red drapery has a greenish tint in the shadows. Orange is the complementary color to blue, yellow is the complementary color to violet, and so through all the list of shades and tones. The primary colors are red, blue, and yellow. A great variety of colors can be made by mixing these colors in different combinations as follows: If Prussian blue is mixed with Indian yellow, a brilliant green is the result. Carmine mixed with Prussian blue produces a beautiful violet. Vermilion mixed with gamboge yellow gives a bright orange. Lamp black mixed with yellow gives a dull green. Burnt sienna mixed with yellow gives a dull orange. By experimenting a little in the mixing of other shades, different tones of color can easily be made. Always remember to soften the edges of objects in painting them; this can be best done with a brush containing only water being passed over the edges of hair or drapery, so as to leave the lines soft and not sharp.

THE NEW GREAT INDIAN PENINSULAR RAILWAY VICTORIA TERMINAL BUILDINGS, BOMBAY.

BOMBAY, the second city in the empire, can now boast of the largest modern architectural work yet erected in India, and the Victoria Terminal Buildings, the name given them on jubilee day, are believed to be the most extensive in the world. The execution of this work occupied ten years, and was completed at the end of May last. The total length of the principal or west facade of the building is over 1,500 feet. The cost of the buildings was about twenty-seven lacs of rupees. The author of the design is Mr. F. W. Stevens, F.R.I.B.A., A.M.I.C.E., late of the public works department, who also supervised the erection of the buildings from the commencement to the end.

The site on which the buildings are erected is one of the finest in the city, and faces that on which it has recently been decided to erect the new municipal buildings, of which Mr. Stevens is also the architect. The style of architecture adopted is a free treatment of Venetian Gothic with an Oriental feeling, which has been proved to be the best adapted for the climate of Bombay. The principal feature of the edifice is the large central masonry octagonal dome, which has a very fine and dignified effect, and can be seen from all parts of the city. The dome is of solid cut stone masonry, and its construction is exposed to view both inside and out. It crowns the grand central staircase of the administrative offices. The drum is pierced by eight two-light lancet windows, glazed with stained glass of ornate design, the arms and monogram of the company being freely introduced. The apex of the dome is crowned by a colossal figure in stone of "Progress," 16 feet 6 inches in height, which has a very imposing effect from below. The principal gables are crowned with groups of colossal sculpture representing Engineering, Architecture, Commerce, Science, and Trade, and under a canopy below the large clock in the central gable is placed a beautiful statue of H. M. the Queen-Empress, typical of the state, the railway being guaranteed by the government. On the piers of the large central entrance gates to the administrative offices are placed colossal figures of a lion and tiger, representing respectively the United Kingdom and India. Medallion heads, in full relief, of various noblemen and gentlemen who have interested themselves more or less in railway enterprise in India have been placed in the circular panels over the outer arches of the corridors. The statuary and heads were executed by Messrs. Earp & Son, Lambeth, under the direct supervision of Mr. W. Emerson, architect.

The interior of the buildings have been most skillfully arranged, and fitted up in an appropriate and artistic manner. Colored polished marbles and granites have been used in the halls, waiting rooms, and refreshment rooms, which have an imposing and pleasing effect. All the foliated sculpture was designed and modeled by Mr. Gomez and the students of the Bombay School of Arts, under the able supervision of Mr. J. Griffiths, the principal. The whole of the work has been carried out by native workmen in a most sub-

GREAT INDIAN PENINSULAR RAILWAY VICTORIA TERMINUS AND ADMINISTRATIVE OFFICES, BOMBAY.

stantial and workmanlike manner, and is equal to anything of the kind in Europe.

The government of Bombay have recorded the eminent services rendered by Mr. Stevens in connection with this vast work, and the directors of the Great Indian Peninsular Railway Company have marked their appreciation of his services by recommending him an honorarium of 5,000 rupees.—*London Graphic.*

THE PALACE OF THE LIBERAL ARTS AT THE FRENCH EXHIBITION.

GROUP II. includes the following classes:

6. Education of infants, primary teaching, instruction of adults.
7. Organization and material for secondary instruction.
8. Organizations, methods, and material connected with advanced teaching.
9. Printing and books.
10. Paper, bookbinding, and materials employed in the arts of painting and drawing.
11. Ordinary applications of the arts of drawing and modeling.
12. Photographs and photographic apparatus.
13. Musical instruments.
14. Medicine and surgery, veterinary and comparative medicine.
15. Mathematical instruments.
16. Maps and other apparatus connected with geography and cosmography. Topography.

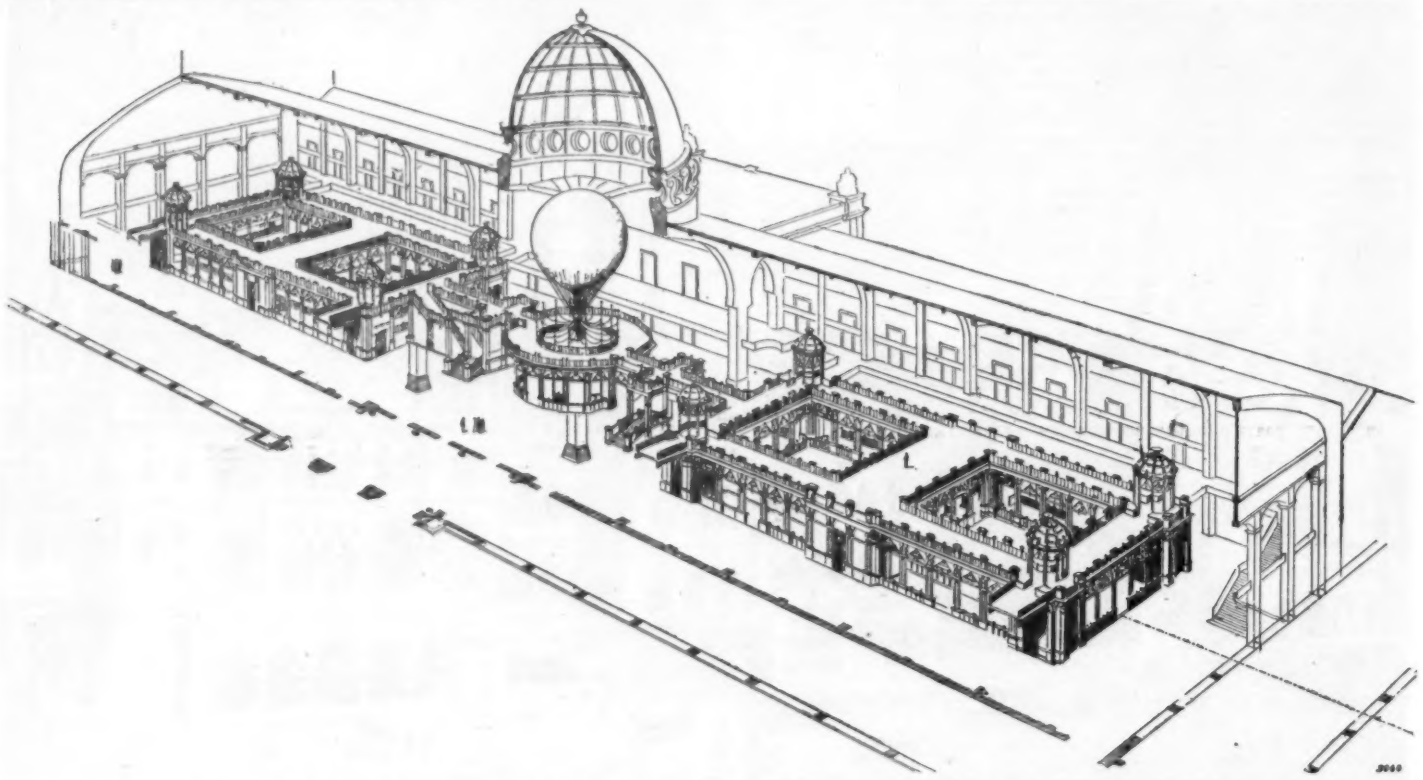
These various classes are distributed in the Liberal Arts Palace, on the ground floor and on the first story.

On the ground floor, along the side adjoining the Avenue de Suffren, will be Classes 14 and 15; near these will be Class 16 on the inner side next to the nave. Class 13 will be placed against the vestibule which separates the building from the gallery of miscellaneous industries. On the first floor, and around the outer galleries, the other classes will be distributed in their numerical order. The minister of the interior will have on the ground floor and on the outer side of the palace an important exhibition of objects connected with his department.

Foreign nations will exhibit each separately in the spaces allotted to them, the grouping being arranged collectively so far as may be possible. Italy will occupy on the ground floor the interior pavilion adjoining the separating vestibule; Switzerland, Belgium, and Holland will be placed in the gallery adjacent to the Avenue de Suffren. On the first floor, England and the United States will each of them fill one of the corner pavilions. The distribution of space and the installation of exhibits are in the charge of M. Sedille, to whom also is due the design of the elaborate and very beautiful internal pavilions made principally of carved wood, which will occupy nearly the whole area of the great central nave, and which will present a variety of ornamental facades, internal galleries, etc. The perspective view that we publish this week gives a good idea of the beauty of this very original structure. This inner pavilion will be devoted to the Retrospective Exhibition of Work and of Anthropological Sciences, which will certainly be one of the most attractive curiosities on the Champ de Mars. The organizing committee of this special exhibition has for its president M. Jules Simon; MM. Jurien de la Graviere and De Quatrefages are vice-presidents. It will comprise five sections: 1. Anthropology, Ethnography. 2. The Liberal Arts. 3. Arts and Industries. 4. Means of Transport. 5. The Art of War.

The special object of this scheme has been clearly set forth in a letter addressed by the president to probable exhibitors; from it we may take a few of its most important paragraphs: "This exhibition will have a special historical and technical interest; it is not intended to exclude works of art, because in various periods, tools, especially those employed in the liberal arts, were true artistic productions, either on account of their elegance of form, their richness of materials, or their beauty of detail. Thus there are often seen real *chefs d'œuvre* on an old map, on the handle of a chisel, or on the barrel of a gun. Our ancestors had not the same passion as ourselves for speed and cheapness; from that order of things the arts benefited and production was limited. Our Exhibition, in presenting a collection of such objects, will gain greatly in brilliancy and attraction. The national museums, the municipal collections, the storehouses of our great workshops, contain large numbers of such objects, which can be easily put in a state fit for exhibition, and which would form the foundation of the proposed collection. The authorities believe that in calling the attention of artists, manufacturers, and collectors to this subject they will probably have suggested a means of making interesting discoveries, and of bringing to light forgotten or unknown treasures of this nature. By the side of the instrument or of the machine may be exhibited the various objects in the production of which these instruments and these machines have been employed, provided always that such objects are of artistic value or of historical importance."

The titles of the various sections are of themselves almost sufficient to indicate the character of each special exhibition. The first, subdivided into anthropology, ethnography, archæology, will comprise prehistoric collections, and will be, to a certain extent, a general review of rudimentary industries; it will illustrate tools in stone and bronze, the origin of glass and of enamel, the early applications of fire to industry, and will institute a comparison between these old-world processes and those of modern savage life. Connected with this section will be the very remarkable creation of M. Garnier, who has constructed at one of the entrances to the Exhibition, upon the river quay, dwellings of various ages and different countries, an extensive series, which will form a history of human habitations.



THE PARIS EXHIBITION OF 1889—THE PALACE OF THE LIBERAL ARTS.

In the section of the liberal arts will be exhibited objects relating to the sciences, to printing, teaching, music, and the theater. It will show a printing office and a bookshop of the sixteenth century, an alchemist's laboratory side by side with one of a modern chemist, and a series of theatrical decorations will certainly command as large a success as the similar collection did in 1878.

The section of arts and industries will be divided into four groups; those relating to the development and utilization of power; the collection and treatment of raw materials; their further elaborations and transformations; the practice of arts and industries necessary to individual and social life. One feature of this collection will be a large number of wax figures representing various periods and costumes, and the industries to which the section refers.

The section relating to means of transport will certainly be one of the most interesting and important. Very curious, also, will be the section relating to the art of war, which will prove an exhibition of high interest, and one which France knows well how to produce.

In examining the plans of the building which it is intended shall contain these various collections, the serious doubt presents itself that there is a vast disproportion between the size of the official programme and the dimensions of the gallery. Pending a solution of this somewhat disquieting suggestion, we may turn to the actual construction of the palace, of which a good idea is given by the perspective view herewith presented, in which the outer walls are supposed to be removed, in order to show the interior. The ironwork of the liberal arts palace—as well as that of the picture gallery—is now completed, and work has entered for some time upon an entirely new phase, which involves a different series of operations—covering the dome with colored tiles and decorating the façades with terra cotta panels. This very considerable work, to which we some weeks ago made a passing reference, is being carried out by Mr. E. Muller. The central dome of each building is about 100 feet in diameter; the upper part, invisible from below, will be glazed. All the rest of the surface will be covered with porcelain tiles, fitting into one another by means of ribs and grooves, so as to form a continuous surface without any overlapping. Altogether each dome will be divided into twelve wide gores separated from each other by narrower ones. The bottom of the former will be white, and in the center, upon a large scroll, will be the initials R. F. in gold surrounded with a turquoise border. The remainder of the surface will be in blue. The mosaic will thus present a combination of blue, red, and yellow on a white ground; and the effect produced, so far as can be judged from the work actually done, will be very satisfactory. The construction of this enameled covering will require no less than 50,000 tiles, of 630 different types, and they will cover a surface of 1,248 square meters. At the foot of each dome will be placed twenty-four large vases 10 feet high. Besides the mosaics on the domes, Mr. Muller has also on hand the decorations of the main central entrances giving on the gardens. The spandrels of the arches are filled in with terra cotta panels representing groups of children, in relief on a gold ground. These panels, 6 feet high, have been finished in one piece—a somewhat remarkable *tour de force*. The liberal arts palace will show, on the side of the Seine, two smaller domes about 60 feet in diamater, and crowning the corner pavilions. These domes will also be covered with enamel tiles in blue and yellow on a cream colored ground; this work is being carried out by MM. Parvillée Brothers. The remainder of the facade will be filled in with large terra cotta panels placed between the iron framework of the building. The edifice will be surmounted by a balustrade constructed by Mr. Muller; it will have an area of 2,000 square meters, and will be formed of about 8,000 pieces of terra cotta, weighing nearly 500 tons.

From what we have said, it will be seen that ceramic art will play a most important part in the construction of these buildings. It is an innovation very cleverly put into practice by M. Formige, who has been ably seconded by the artists with whom he has surrounded himself.—*Engineering.*

NEW MIXTURE FOR SEPARATING CARBON FROM PIG IRON, STEEL, ETC.

By T. W. HOGG.

THE most accurate methods that have been proposed for the determination of carbon in steel, pig iron, and other ferro-carbon alloys are those in which the carbon is first separated in a state of proximate purity, and afterward burnt in a current of oxygen.

In order that this separation may be effected, it is simply necessary to treat the particular ferro-carbon alloy with some salt whose base can either be substituted entirely, or where the salt can be reduced to some lower compound by the iron present in the alloy; the carbon not taking any part in the reaction is left behind as such, and may be filtered off for further treatment.

It is obvious that quite a considerable number of salts are capable of effecting this separation, and a great many have been recommended for the purpose, but none of them have given such general satisfaction as a neutral solution of cupric chloride. However, even this cupric chloride possesses one objectionable quality—the decomposition of the alloy is accompanied by the production of cuprous chloride, and, as this is comparatively speaking an insoluble compound, it is necessary to provide against its precipitation; this is accomplished by adding an abundance of concentrated hydrochloric acid, or by having present in great excess a saturated solution of some salt, such as sodium or ammonic chloride.

Whatever plan may be adopted, this insolubility of the cuprous chloride is always troublesome, and occasionally proves an intolerable nuisance; and it is the object of this short paper to draw attention to a reac-

tion familar to every chemist, by means of which this inconvenience may be entirely removed.

When a solution of ferric chloride is added to cuprous chloride an immediate change takes place, cupric chloride and ferrous chloride being formed.

The ferric chloride solution may be utilized in different ways by the operator; he may conduct the analysis by means of cupric chloride as usual, and at the end decompose the cuprous chloride by adding sufficient ferric chloride, or he may add this salt as soon as the mixture of metallic copper and carbon is obtained. A little gentle heating, aided by a few drops of hydrochloric acid, will suffice to cause the whole of the metallic copper to be dissolved by the ferric chloride.

The ferric chloride may be used in a still more advantageous and economical point of view; it will itself, as is well known, decompose most ferro-carbon alloys, but not without some loss of carbon; but if a small proportion of cupric chloride be present, this loss is entirely prevented. The decomposition proceeds entirely through the medium of the copper salt, which is at first reduced and then reformed at the expense of the ferric chloride.

The ferric chloride should possess a sp. gr. of about 1·30, and the copper salt 1·35, but so long as these solutions are kept pretty concentrated, the exact strength is not a matter of very great consequence; a little ammonium hydrate should be added to neutralize any excess of free acid that might be present. The ferric chloride will dissolve ferric hydrate long after all free acid is neutralized, so that it is best to try the mixture with a high carbon steel, and ascertain whether there is any indication of the evolution of hydrocarbons.

After weighing the requisite quantity of the alloy, and placing it in a beaker, sufficient cupric chloride is added to cover the borings to the depth of about half an inch, and then a considerable excess of the ferric chloride solution is added; after about five minutes' stirring the beaker is placed upon a lamp and heated gently up to boiling point, and if the borings have been in the proper state of fineness, the decomposition will be completed within twenty minutes, and, after adding a few drops of hydrochloric acid, to prevent the precipitation of basic compounds, the carbonaceous residue may be filtered off, and washed prior to further treatment.

In dealing with alloys containing silicon up to about 4 per cent. the carbon should always be filtered off as soon as the alloy is quite decomposed; it is a common occurrence to allow the borings and the cupric chloride to stand all night, and, if this is done, the silicic acid which results from the oxidation of the silicon, and which at first passes almost entirely into solution, is often partially precipitated in the gelatinous condition, with the result that the filtration becomes very tedious. —*Chemical News.*

[Continued from SUPPLEMENT, No. 676, page 10801.]

ALLOYS.*

By Professor W. CHANDLER ROBERTS-AUSTEN, F.R.S.

LECTURE III.†

TWENTY-FOUR years ago the accomplished artist, architect, and antiquary, the late Mr. William Burges, delivered a course of Cantor lectures before the Society of Arts.‡ He stated that he "had been requested by the council to show how the arts have formerly been applied to industry; how they are at present applied; and what may possibly be done to increase their application." Mr. Burges dwelt at some length on bronze, brass, gold, and silver, and his lectures, generally, were considered to be so important that the present director for art at South Kensington made them the text for an address delivered before this Society in February, 1887, when he reviewed the progress which has been made during the past thirty years. But you will say the metallurgist cannot speak with authority on themes such as these; I have, however, treated the subject in a manner which will, I believe, enable me to bring before you important truths affecting a wide range of industrial operations, and, at the same time, to sustain the true function of art by pointing to the direction in which we may have increased pleasure in things that constitute our most ordinary possessions, and which we use in daily life. First, permit me to explain that I intend to include under the title of the lecture any facts which are, in my opinion, connected with the colors of metals and alloys, whether natural to them or produced by artifice, as well as a brief examination of the influence which the colors of metals appear to have exerted on the history of science.

I propose to begin at what will appear to be a somewhat remote starting point. We say that copper is red, gold yellow, and silver white, but it is by no means certain that the early races of the world had any very clear perception of the difference between these several metallic colors. With regard to early Hebrew and Greek civilization, Mr. Gladstone has expressed his belief that the color-sense—that is, the power of recognizing color and distinguishing it from mere brightness or darkness—was imperfectly developed, and he considers that "the starting point is absolute blindness to color in the primitive man," and he urges that the sense of color has been gradually developed "until it has now become a familiar and unquestioned part of our inheritance." He adds: "Perhaps one of the most significant relics of the older state of things is to be found in the preference (known to the manufacturing world) of the uncivilized nations for strong and, what is called in the spontaneous poetry of trading phrases, loud color."§

Dr. Magnus holds the view that the color sense in man has undergone a great improvement within the last 2,000 years, and Professor Haeckel supports this speculation. But it is opposed by Romanes, who has favored me with some observations on the subject, in view of this lecture; and it seems to me strange, if savage nations are really deficient in the sense of color, that the use of such colors as they can get in metals and fabrics, blended, for instance, in a war club or a pipe stem, should be so thoroughly "understood" and so discriminately employed as we sometimes find them to be. It may further be observed that primitive man may even have derived from his more remote ancestry some power of being influenced by color, and we are told that the attraction which gorgeous coloring in flowers has for birds and insects, and which color generally possessed for our nearer ancestors, has been of great importance in the origin of species and in the maintenance of organic life.

No doubt in ancient times there was much confusion between mere brightness and color, such as is evident in the beautiful sentence in which St. Augustine* says: "For this queen of colors, the light, bathing all which we behold, wherever I am through the day, gliding by me in varied forms, soothes me when engaged on other things, and not observing her." If, however, it were proved that the power of distinguishing the color of metals was not widely diffused among the Egyptians, Hebrews, and Greeks, it is at least certain that there were individuals of these nations to whom, in very early times, the color of metals was all-important; and although they may have confused different precious stones under generic names, they certainly appreciated their various colors, and knew, moreover, that by fusing sand with the addition of a small quantity of certain minerals they could produce artificial gems of varied tints.

My object in leading you so far back—in discussing what appears to be a very matter-of-fact subject—is to point to the close connection between the early recognition and appreciation of color in metals or minerals and the foundation of the science of chemistry.

In early scientific history the seven metals known to the ancients were supposed to be specially connected with the seven principal planets whose names they originally bore, and whose colors were reflected in the metals. Thus gold resembled the sun, silver the moon, while copper borrowed its red tint from the ruddy planet Mars. The belief in the intimate relation between colors and metals, the occult nature of which they shared, was very persistent, and we find a seventeenth century writer, Sir John Pettus, saying† that "painters" derive "their best and most proper colors from metals, whereof seven are accounted the chief, produced from the seven chief metals, which are influenced by the seven planets." A survival of this feeling is suggested by a modern writer, Leslie, who supposed that "when Newton attempted to reckon up the rays of light decomposed by the prism, and ventured to assign to them the famous number seven, he was apparently influenced by some lurking disposition toward mysticism."‡

It would be impossible for me to overrate the importance of the color of metals in relation to scientific history, for the attempt to produce a metal with the color and properties of gold involved the most intense devotion to arduous research, sustained by feverish hope, attended by self-deception and elaborate fraud, such as hardly any other object of human desire has developed. It led to despair, to madness, and to death; but finally, through all, alchemy prepared the way for the birth of chemistry and for the true advancement of science.

In early times, as now, gold was an extremely desirable form of portable property, and its color was, perhaps, held to be the most distinctive and remarkable fact about it. I may incidentally observe that the dominant idea of color in connection with the metallic currency survives in the familiar phrase, "I should like to see the color of his money," which curiously expresses a desire, tempered by doubt as to its fulfillment. On looking back, we find that, at least from the third to the seventeenth century, the color of gold haunted the early experimenters, and induced them to make the strangest sacrifices, even of life itself, in the attempt to imitate, and even actually to produce, the precious metal. Let us see what kind of facts were known within the period I have indicated. In barbaric times, hammered pieces of gold, or gold beaten into thin sheets or plates, were used with colored stones and coral for personal adornment. The next step was to make gold go further by gilding base metals with it, and, in order to do this, the color was for the moment sacrificed by combining the gold with quicksilver. This was done at least in the time of Vitruvius, B. C. 80, heat being used to drive away, as vapor, the quick silver which had been united to the gold, leaving a thin film of precious metal on the surface to be gilded. But this was possibly not the first method of gilding, for we now know, from a papyrus of about the third century§ of our era, that lead was used for this purpose. Gold, when fused with lead, entirely loses its golden color, and yet, by the application of heat in air, the lead may be made to flow away as a fusible oxide, leaving the precious metal on the metallic object to be gilt, the base metal being as it were transmuted, superficially at least, into gold. The point I want to insist upon is that the metallic color of the gold vanished during the process as carried on by the craftsman, only to reappear at the end of the operation; and I am satisfied that it was from such simple technical work as this that the early chemists were led to think that the actual production of gold—the transformation of base metals into gold—was possible. The more observant of them, from Geber, the great Arabian chemist of the seventh century, to our own countryman, Roger Bacon, in the thirteenth, saw how minute a quantity of certain substances would destroy the red color of copper or the yellow color of gold. A trace of arsenic will cause the red color of copper to disappear; therefore, the alchemists very generally argued, some small quantity of the right agent, if only they could find it, will turn a base metal to the color of gold. Look, they said, how small a quantity of quicksilver will change the appearance of metallic tin. Here is a bar of tin two feet long and one inch thick, which it would be most difficult to break, though it will readily bend double. If only I rub a little quicksilver on its surface a remarkable effect will be produced, for the fluid metal will penetrate the solid one,* and in a few seconds the bar will, as you see, break readily, the fractured surface being white, like silver. It was by such facts as this that men were led to believe that the white metal, silver, could be made.

Successive workers at different periods held divergent views as to the efficacy of the transmuting agent. Roger Bacon, in the thirteenth century, held that one part of the precious substance would suffice to turn a million parts of base metal into gold. Basil Valentine, in the fourteenth century, would have been content with the transmutation of seventy parts of base metal by one part of the agent; while, coming to the end of the eighteenth century, Dr. J. Price, F.R.S., of Guildford, only claimed that the substance he possessed would transmute from thirty to sixty parts of base metal.†

It is a curious fact that no one seems to have actually prepared the transmuting agent for himself, but to have received it in a mysterious way from a "stranger;" but I must not dwell on this. I will merely point out how persistent was the view as to the singular efficacy of the transmuting agent, and I will content myself with a reference to Robert Boyle, our great countryman, an accurate chemist of the seventeenth century, who did more than any one else to refute the errors of alchemy. He, nevertheless, characteristically records the following experiment,‡ in which, instead of ennobling a base metal, he apparently degraded gold to a base one. He first purified a small quantity of gold, about "two drachms," with great care, and, he states, "I put to it a small quantity of powder communicated to me by a stranger"—it is singular that even he should have received the transmuting agent in the usual way—"and" he adds, "continuing the metal a quarter of an hour on the fire, that the powder might diffuse itself through it, ... the metal when cold appeared to be a lump of dirty color. . . . . It was brittle, and, being worked with a hammer, it flew into several pieces. From hence," he adds, "it appears that an operation almost as strange as that called 'projection'" (or transmutation) "may safely be admitted, since this experiment shows that gold, ... the least mutable of metals, may in a short time be exceedingly changed . . . . by so small a portion of matter that the powder transmuted a thousand times its weight of gold." He elsewhere observes of a similar experiment, "Transmutation is nevertheless real for not being gainful, and it is no small matter to remove the bounds which Nature seems very industriously to have set to the alterations of bodies."§ The change in the color of the gold was remarkable, but Boyle had only produced one of the series of alloys most dreaded by every jeweler—"brittle gold"; for the way in which an alloy of gold and copper is affected by a small quantity of impurity presents one of the most serious difficulties in working gold. It has been known since the seventh century that minute quantities of certain metals change the color of gold and render it brittle, and it may be well to demonstrate the fact.

Here are two hundred sovereigns; I will melt them, and will add in the form of a tiny shot a minute portion of lead amounting to only the 2,000th part of the mass, first, however, pouring a little of the gold into a small ingot, which we can bend and flatten, thus proving to you that it is perfectly soft, ductile, and workable. The rest of the mass we will pour into a bar, and now that it is sufficiently cold to handle, you see that I am able to break it with my fingers, or, at least, with a light tap of a hammer. The color of the gold is quite altered, and has become orange-brown, and experiments have shown that the tenacity of the metal, that is, the resistance of the gold to being pulled asunder, has been reduced from eighteen tons per square inch to only five tons. These essential changes in the property of the metal have been produced by the addition of a minute quantity of lead. I have cited these facts mainly to show that the changes produced in the color and properties of metals by small variations of composition were such as to lead the alchemists on in their belief that it was possible to change lead or tin into gold, and the hope in which they worked enabled them to gather facts out of which chemical science was gradually constructed. We shall see presently that changes in the color of metals and alloys produced by the addition of small quantities of foreign matter are of great importance in the application of metals to artistic purposes, but we must first try to examine more closely some of the prominent facts connected with the color of metals, that is, the effect metals have on light, so as to produce the effect of color in our eyes. We are apt to think of gold as being essentially and distinctly of golden-yellow; it may, however, possess a wide range of colors without in any way losing the condition of absolute metallic purity, its relations to light depending entirely on the nature of its surface, and especially on whether the metal is in mass or in a more or less fine state of division. Interesting as gold is to us in mass, it is, perhaps, still more interesting to us when beaten so fine that a single grain, of the value of 2d., would cover a space of forty-eight square inches, or when it is so finely divided that the dimensions of a single particle may closely approximate to those of the ultimate atom.

This aspect of the question was investigated by Faraday, and the experimental part of the subject as regards gold remains practically as he left it. It is well known that a leaf of gold, when seen by transmitted light, is either green or blue, according to its thickness. Here is such a leaf of green gold, as seen when light is actually sent through it (Fig. 1), so as to project a green disk on the screen. A portion of the light will be reflected from its surface, and this reflected ray may be caught in a mirror and thrown on the screen, so that you have, shown side by side, the green disk of transmitted light and the golden one of reflected light from the same leaf of gold.

Gold may readily be converted into a soluble chloride which produces a beautiful golden solution. If such a solution contains very little gold, not more than

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* Three lectures delivered before the Society of Arts, London, 1888. From the *Journal* of the Society.

† This lecture was originally delivered in 1886, to the operative classes of Birmingham, in connection with the British Association. It is now published in this *Journal* as modified for delivery before the Society of Arts, in order that it may form part of the series of lectures (delivered by the author) which began, in 1884, with a course of four lectures on "Alloys Used for Coinage."

‡ "Art Applied to Industry," by W. Burges. 1865.

§ "Nineteenth Century," p. 307, 1877.

* "Confessions of St. Augustine." Edition edited by E. B. Pusey, D.D. (p. 211).

† "Treatises on Various Subjects of Natural and Chemical Philosophy."

‡ "Fleta Minor," 1686, appendix, "Essay on Metallic Words: Color."

§ "Les Origines de l'Alchimie," par M. Berthelot, 1885, pp. 82, 89. It is interesting to compare the account of this method of gilding by lead with the expression used by Homer, who says: "As when gold is fused around the silver by an experienced man." "Odyssey," vi. 232–35, quoted by Schliemann, "Ilios," p. 258, in relation to a gilded knife of copper which he permitted me to analyse in 1878.

* Homberg, "Mem. de l'Acad. Royale des Sciences," 1713 (vol. published 1739), p. 306.

† "An Account of Some Experiments on Mercury, Silver, and Gold made at Guildford, in the Laboratory of James Price, M.D., F.R.S.," Oxford, 1782.

‡ "The Philosophical Works of the Hon. Robert Boyle" (Shaw's second edition), 1738, vol. i., p. 78.

§ Loc. cit., vol. i., p. 302.

two grains in a gallon, and if certain chemical methods be adopted to precipitate the gold, that is to throw it out of solution in a solid, though in a very fine state of division, the metal may exhibit a wide range of tint, from ruby to black.

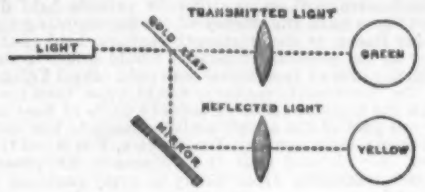

FIG. 1.

[A few drops of phosphorus dissolved in bisulphide of carbon had been added to about a gallon of a very dilute solution of chloride of gold contained in a tall glass cylinder, as shown in the sketch (Fig. 2). The beam from an electric light, thrown through the vessel, revealed in the lower part the presence of finely divided metal of the natural golden color, while the more finely divided gold in suspension imparted a brilliant ruby color to the liquid, and a glowing ruby disk was projected on a white screen.]

FIG. 2.

When gold is in the "ruby" state it is so finely divided that each particle probably approximates to the dimensions of the gold atom.

[The spectrum was then thrown upon the screen, and the audience was invited to compare it with a diagram which, while closely resembling the solar spectrum, really represented the way in which pure metallic gold, prepared by various methods, is capable of behaving in relation to light so as to possess a wide range of colors.]

It would be easy to show that light is similarly affected by other metals, but I have selected gold for the purpose of illustration because it is easy to maintain it in a state of purity, however finely divided it may be. We must therefore modify any views we may have formed as to a metal having exclusively a special color of its own, because it will be evident that a particular color is only due to a definite state of arrangement of its particles. The intimate relation between the state of the surface of a metal and its color is well shown by the beautiful buttons devised by Sir John Barton. He proved that if very fine lines be drawn close together, so that about 2,000 would be ruled in the space of an inch, a beautiful iridescent effect is produced, the tints being quite independent of the metal itself, due to an optical effect of the lines.

[The image of such a button was then thrown upon the screen.]

Let us now examine some effects of uniting metals by fusing them together into what are called alloys; and, second, the direct influence of a minute quantity of one metal in changing the mass of another in which it is hidden, and causing it to behave in a different way in relation to light, and consequently to possess a color different from that which is natural to it; or the added metal may so change the chemical nature of the metallic mass that varied effects of color may be produced by the chemical combinations which result from the action of certain "pickling" solutions. This portion of the subject is so large that I can only hope to set before you certain prominent facts.*

First, with reference to the color produced by the union of metals. Here is a mass of red copper, and here one of gray antimony; the union of the two by fusion produces a beautiful violet alloy when the proportions are so arranged that there is 51 per cent. of copper and 49 per cent. of antimony in the mixture. This alloy was well known to the early chemists, but, unfortunately, it is brittle and difficult to work, so that its beautiful color can hardly be utilized in art. The addition of a small quantity of tin to copper hardens it, and converts it, from a physical and mechanical point of view, into a different metal. The addition of zinc and a certain amount of lead to tin and copper confers upon the metal copper the property of receiving, when exposed to the atmosphere, varying shades of deep velvety brown, characteristic of the bronze which has from remote antiquity been used for artistic purposes. But by far the most interesting copper alloys, from the point of view of color, are those produced by its union with zinc, namely, brass. Their preparation demands much care in the selection of the materials, and I might have borrowed from the manufacture of brass instance after instance of the influence of traces of impurity in affecting the properties of the alloy, for I have many inducements in this place to speak about this beautiful alloy. I am proud to be a namesake of the craftsman, William Austen, who, in 1460, made that magnificent monument in brass which covers the remains and commemorates the greatness of Richard Beauchamp, Earl of Warwick, and I am glad to remember that Queen Elizabeth granted the first patent for the manufacture of brass in England to William Humfrey, Assay Master of the Mint, a predecessor in the office it is my privilege to hold.

I want, however, to direct your attention to-night to some alloys of copper with which you are probably less familiar than with brass. In this direction Japanese art affords a richer source of information than any other. Of the very varied series of alloys the Japanese employ for art metal work, the following may be considered the most important and typical. The first is called "shaku-do;" it contains, as you will observe from Analyses I. and II.,*

SHAKU-DO.

I.

Copper	94·50
Silver	1·55
Gold	3·73
Lead	0·11
Iron and arsenic	traces
	99·89

II.

Copper	95·77
Silver	0·08
Gold	4·16
	100·01

in addition to about 95 per cent. of copper, as much as 4 per cent. of gold. It has been used for very large works. Colossal statues are made of it, one cast at Nara in the seventh century being specially remarkable. The quantity of gold is, however, very variable; specimens I have analyzed contained only 1·5 per cent. of the precious metal. The next alloy to which I would direct your attention is called "shibu-ichi." There

SHIBU-ICHI.

III.

Copper	67·31
Silver	32·07
Gold	traces
Iron	0·52
	99·90

IV.

Copper	51·10
Silver	48·93
Gold	0·12
	100·15

are numerous varieties of it, but in both these alloys, shaku-do and shibu-ichi, the point of interest is that the precious metals are, as it were, sacrificed in order to produce definite results, gold and silver, when used pure, being employed very sparingly to heighten the general effect. In the case of the shaku-do, we shall see presently that the gold appears to enable the metal to receive a beautiful rich purple coat or patina, as it is called, when treated with certain pickling solutions; while shibu-ichi possesses a peculiar silver gray tint of its own, which, under ordinary atmospheric influences, becomes very beautiful, and to which the Japanese artists are very partial. These are the principal alloys; but there are several varieties of them, as well as combinations of shaku-do and shibu-ichi in various proportions, as, for instance, in the case of kiu-shibu-ichi, the composition of which would correspond to one part of shaku-do rich in gold and two parts of shibu-ichi rich in silver.

Now as to the action of pickling solutions. Many of you will be familiar with the mysteries of the treatment of brass by "dipping" and "dead dipping," so as to produce certain definite surfaces; but the Japanese art metal workers are far ahead of their European brothers in the use of such solutions.

The South Kensington Museum contains a very valuable series of fifty-seven oblong plates, some plain and others richly ornamented, which were specially prepared as samples of the various metals and alloys used by the Japanese. The Geological Museum in Jermyn street has a smaller but very instructive series of twenty-four plates, presented by an eminent metallurgist, the late Mr. Hochstatter-Godfrey. From descriptions accompanying the latter, and from information I have gathered from certain Japanese artificers now in London, it would appear that there are three solutions generally in use. They are made up respectively in the following proportions, and are used boiling:

	I.	II.	III.
Verdigris	438 grains.	87 grains.	220 grains.
Sulphate of copper	292 "	437 "	540 "
Niter	—	87 "	—
Common salt	—	146 "	—
Sulphur	—	583 "	—
Water	1 gal.	—	1 gal.
Vinegar	—	1 gal.	5 fluid dr.

That most widely employed is No. 1. When boiled in No. III. solution, pure copper will turn a brownish red, and shaku-do, which, you will remember, contains a little gold, becomes purple. And now you will be able to appreciate the effect of small quantities of metallic impurity as affecting the color resulting from the action of the pickle. Copper containing a small quantity of antimony gives a shade very different from that resulting from the pickling of pure copper. But the copper produced in Japan is often the result of smelting complex ores, and the methods of purification are not so perfectly understood as in the West. The result is that the so-called "antimony" of the Japanese art metal workers, which is present in the variety of copper called "kuromi," is really a complex mixture containing tin, cobalt, and many other metals, so that a metal worker has an infinite series of materials at command with which to secure any particular shade; and these are used with much judgment, although the scientific reasons for the adoption of any particular sample may be hidden from him. It is strictly accurate to say that each particular shade of color is the result of minute quantities of metallic impurity, and these specimens and diagrams will, I trust, make this clear, and will prove that the Japanese arrange true pictures in colored metals and alloys.

[This portion of the subject was illustrated with much care by colored diagrams representing specimens of Japanese art metal work, by photographs projected on the screen, as well as by the reflected images of small ornaments made of the alloys which had been specially referred to. There was also a trophy of large leaves of copper of varying degrees of purity, colored brilliantly by one or other of the "pickles" above described.]

There is one other art material to the production of which I hope art workmen in this country will soon direct their attention, as its applications are endless. It is called in Japanese "mokumè," which signifies "wood grain." It is now very rare, even in Japan, but formerly the best specimens appear to have been made in Nagoya by retainers of the Daimio of Owari. I have only seen six examples, and only possess a single specimen of native work, and have therefore had to prepare a few illustrations for you in soldered layers of gold, silver, shibu-ichi, shaku-do, and kuromi.

This diagram (Fig. 3) shows the method of manufacture. Take thin sheets of almost any of the alloys I have mentioned, and solder* them together layer upon layer, care being taken that the metals which will present diversity of color come together. Then drill conical holes of varying depth, A, in the mass, or devices in trench-like cuts V section, B, and hammer the mass until the holes disappear; the holes will thus be replaced by banded circles, and the trenches by banded lines. A Japanese artificer taught me to produce similar effects by taking the soldered layers of the alloy, and, by the aid of blunted tools, making depressions on the back of the mass, so as to produce prominences on the front, C. These prominences are filed down until the sheet is again flat; the banded alloys will then appear on the surface in complicated sections, and a very remarkable effect is produced, especially when the colors of the alloys are developed by suitable "pickles." In this way any device may be produced. In principle, the method is the same as that which produces the damascening of a sword blade or gun barrel, and depends on the fact that under certain conditions metals behave like viscous solids, and as truly "flow" as pitch or honey does, and in the case of mokumè the art workman has a wide range of tinted metals at command.

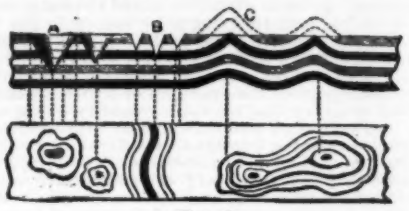

FIG. 3.

Since this lecture was delivered I have succeeded in preparing some elaborate specimens of mokumè, and the artistic merits of the material have been recognized by Mr. Alfred Gilbert, A.R.A., who is employing it in the exquisite *repoussé* metal work which he alone can produce.

Throughout Japanese art metal work, in which I hope you will take increasing interest, there is the one principle of extreme simplicity and absolute fidelity to nature. The brilliant metals, gold and silver, are used most sparingly, only for enrichment, and to heighten the general effect; these precious metals are never allowed to assert themselves unduly, and are only employed where their presence will serve some definite end in relation to the design as a whole. A Japanese proverb asserts that "he who works in gold puts his brains into the melting pot," meaning, I suppose, that this metal, so precious from an artistic point of view, demands for its successful application the utmost effort of the workman, and suggesting that gold should not be employed in massive forms such as would result from melting and casting, but should be daintily handled, beaten on to the work, or embedded with the hammer.

Bear in mind that in Birmingham, when a really fine work is produced in silver, the surface is often made gray by chemical means, "oxidized," as it is termed, and this subordination of the brilliancy of silver to artistic effect is well understood by the celebrated American firm, Messrs. Tiffany, of New York, who are doing so much to catch the spirit of Japanese art metal work. All I ask artists to do is to carry this still further—to cover base metals with these glowing colored oxides, and thus to add to the permanence of art work by producing surfaces which will resist the unfavorable atmospheric influences of our cities.

The Oriental art metal workers often blend metals and alloys of different colors by pouring them together at a temperature near the solidifying point of the more infusible of the metals and alloys to be associated. In this way, by pouring the comparatively fusible gray silver-copper alloy on to fused copper which is just at the point of "setting," the metals unite, but do not thoroughly mix, and a mottled alloy is produced. The Japanese use such alloys in almost every good piece of metal work.

The art of complex casting has been practiced in India for a thousand years or more, almost exclusively in the Presidency of Madras, as I am informed by Mr. C. Purdon Clarke, C.I.E., to whom I am indebted for the image of Hanuman (Fig. 4), the monkey ally of the good Rama. It was analyzed in my laboratory at the School of Mines by Mr. Arthur Wingham. The face, legs, and arms are of rich bronzed copper, while the dress is of yellow brass, the metals being so skillfully blended that no signs of joins or added pieces can be detected. A section cut vertically through the figure revealed the fact that the brass had been cast over a

* A list of books and papers dealing with the colors of metals and alloys, and with the production of colored patina, is given by Professor Ledebur in his work "Die Metallverarbeitung," p. 285, 1882, published in Bolley's "Technologie."

* Analyses Nos. I. and III. are by Mr. Gowland, of the Imperial Japanese Mint at Osaka; Nos. II. and IV. by Prof. Kalischer, "Dingl. Polyt. Journ.," ccxv., 93.

* The following solder was found to answer well:

Silver	55·5
Zinc	26·0
Copper	18·5
	100·0

roughly fashioned solid core of copper, which is less fusible than brass. This investing layer of brass could be readily cut away, and finished so as to leave only the dress and delicate anklets and bracelets on the copper limbs. The method of *cera perduta* was probably used in the production of such castings.

a. b.

a. Image of Hanuman in copper and brass. The dark cross lines of the section of the figure (*b*) indicate the relation of the copper core to the investing layer of brass, which is marked with lighter section lines.

FIG. 4.

Hitherto we have considered the union of metals by fusion, but fire is not the only agent which can be employed for this purpose. Two or more metals may be deposited side by side by the aid of the electric battery. Birmingham was, as you well know, the early home of electro-metallurgy, an industry to the development of which the great firm of Elkington has so materially contributed. I have no statistics as to the amount of precious metals annually employed for electro-deposition in Birmingham, but it is known that a single works in Paris, belonging to M. Christofle, deposits annually six tons of silver, and it has been estimated that the layer of silver of the thickness actually deposited on various articles would, if spread out continuously, cover an area of 140 acres.* I will not, however, dwell upon the deposition of gold and silver in their normal colors. I would remind you that copper and zinc may be deposited by electrolysis so as to form brass, and that all the beautiful bronzes and alloys of the Japanese can be obtained by galvanic agency; and further, by suitable admixtures of gold, silver, and copper, red gold, rose colored gold, or green gold may be deposited, so that the electro-metallurgist has at his command the varied palette of the decorative artist.

[The images of beautiful deposits of colored gold, specially prepared by Messrs. Elkington, were then produced on the screen.]

I ought to allude to what has been called the moral aspect of color, and although I cannot follow Goethe† in his attributes of color, which seem to me to be fantastic and overstrained, I quite recognize the poetic sympathy of Shakespeare in making Bassanio select the casket of lead which contained the warrant for his earthly happiness, because "its paleness moved him more than eloquence." I ask you to remember Ruskin's words, that "all men completely organized and justly tempered enjoy color; it is meant for the perpetual comfort and delight of the human heart; it is richly bestowed on the highest works of creation, and the eminent sign and seal of perfection in them being associated with life in the human body, with light in the sky, with purity and hardness in the earth; death, night, and pollution of all kinds being colorless."

I must briefly turn to the concluding part of our subject. It has long been known that thin films of certain metals and certain metallic oxides act on light in the same way as thin films of other translucent substances; and since this lecture was originally delivered, at Birmingham, Dr. A. Kundt has published a very interesting paper‡ to which reference should be made. He has with great care and difficulty prepared sufficiently thin transparent metallic prisms, and by their aid has determined the mean refractive index for seven metals, and for six of them the direction and approximate value of the dispersion. Dr. Kundt has been led to the conclusion that "the velocity of light in the metals stands in close relationship to their power of conducting electricity and heat; for in respect to the velocity of light the metals range themselves in the same order as in respect of their conductivity for electricity and heat." The important generalization that alloys conduct electricity and heat in the same order I have already referred to in the first lecture.

I have here thin films of oxide of lead, which, many years ago, Nobili, Becquerel, and Gassiot taught us to deposit, and such films have since been used in decorative metal work.

[Carefully prepared examples of such films were projected on the screen.]

I wish I had time to point to the great interest and importance of films of colored oxide of iron in the tempering of steel, for it is well known that, apart from the scientific interest of the subject, the shades from straw color to blue which pass over the surface of hardened steel when it is heated in air afford precious indications as to the degree of temper the metal has attained, and in no industry is this better shown than in the manufacture of steel pens. I must pass this over, and turn to one other instance of the formation of colored films on metals.

Here is an ordinary plumber's ladle (Fig. 5) filled with

FIG. 5.

lead, which will soon be molten when it is placed over this flame. The air will play freely on the surface of the melted lead, and, as a certain temperature is reached, very beautiful films will pass over the surface of the metal. If the lead contains very minute quantities of cadmium or antimony, the effect will be greatly heightened. If the light from the electric lamp be allowed to fall on the surface of the bath of lead, it will be easy to throw the image of the metallic surface on the screen, and you will see how beautiful the films are and how rapidly they succeed each other when the metal is skimmed. What, then, is the special significance of the experiment from our point of view? It represents in a singularly refined way the one experiment which stands out prominently in the whole history of chemistry; for the formation of a colored scum on lead when heated in air has been appealed to, more than any other fact, in support of particular sets of views, from the time of Geber in the 7th century to that of Lavoisier in the 18th. It was the increase in weight of the lead when heated in air that so profoundly astonished the early chemists; and finally, the formation of a colored oxide by heating lead in air was the important step which led Priestley* to the discovery of oxygen; and Birmingham may claim to have been connected, through him, with one of the most splendid contributions ever offered to chemical science.

I have tried to set before you many of the more important facts which have been deduced from modern researches on alloys, but it has not been possible in this brief course of lectures to deal with the results of the very promising and fruitful thermo-chemical methods of investigation, and which have enabled a distinction to be made between true combinations of metals with each other and mere mixtures or solutions of metals. The following is an outline of the principles by which experimenters have been guided. When a chemical compound is formed, heat is evolved and energy is lost. If, on the other hand, one metal simply dissolves another, the solution would be attended with absorption of heat, and the product, when attacked by a suitable reagent, should liberate practically the same amount of heat, but certainly not less than would be evolved by the individual metals present in association. Proceeding on such a basis, Berthelot, whose calorimetric method is well known, examined amalgams of sodium and potassium with mercury.† Troost and Hautefeuille,‡ by attacking carburized iron with chloride of mercury, and measuring the heat liberated, showed that the carbon in cast iron and steel was probably dissolved and not combined—a result of great importance. Recently M. Joannis, § by decomposing alloys of potassium and sodium by water in a calorimeter, has been led to the conclusion that the alloy NaK_2 is the only one of the potassium-sodium series which is a true compound.

The guidance of the well-known law of Dulong and Petit has been valuable in examining the constitution of alloys, and it has, moreover, long been recognized that the specific heats of alloys approximate to the means of those of their constituent metals. Recently M. Pionchon has shown ‖ that the specific heats of alloys of platinum containing 10 per cent. of iridium, and of platinum containing 12 per cent. of palladium, bear out the view that the metals are simply mixed. On the other hand, Pionchon and Le Chatelier ** have, independently and by different methods, shown that at a temperature of about 700° C. iron passes into an allotropic state, and Osmond †† has further proved that in carburized iron a change in the relation of the carbon and iron takes place during its cooling from a high temperature. The evidence as to molecular change in metals is thus being made very clear, and it is to be hoped that by adopting such methods it will be possible to trace many cases of the passage of alloyed metals into allotropic states.

In this course of lectures my object has been to direct your attention to modern views concerning the constitution of alloys. I have, therefore, hardly touched upon their industrial applications, and have set aside entirely the consideration of the mechanical properties which render them so useful in building and machine construction. You will, I trust, have seen that the scientific importance of alloys is now being recognized, and that they well deserve the most careful study.

HARCOURT'S HOLOPHOTOMETER.

As its name implies, this new photometer of Mr. Harcourt's is designed for measuring the light emitted

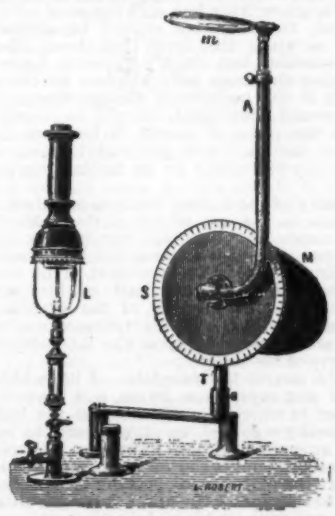

FIG. 1.

in every direction by a luminous source. It is based upon the use of the Bunsen screen, but comprises a system of mirrors that permits of making measurements at different angles.

The apparatus has been devised with a view to the avoidance of the two sources of errors that present themselves in such measurements, viz., the one due to the movements that it is necessary to make one of the sources to undergo, and the one due to the fact that, in lamps provided with reflectors, the distance from the source to the screen must not be counted starting from the flame itself, but from the focus of the reflector.

With a photometer whose bar has a fixed length, it is not easy to see whether this fact introduces an error and what the amount of it is. For this, it is necessary to vary the length of the bar.

To this effect, the lamp to be measured and the system of mirrors are not connected with the bar, but are placed upon a separate table that may be brought near to, or removed from, the movable screen on the bar.

The apparatus consists of two mirrors, one of which (the larger), M (Fig. 1), is fixed through friction to the extremity of a horizontal axis, T. The center of the mirror corresponds to the center of the axis, but the mirror can be inclined at any angle whatever. This axis is arranged at the level of the Bunsen screen and in the direction of the axis of the photometer. At the other extremity is hinged a slide arm, A, provided at the top with a small mirror, *m*. From this arrangement, it will be seen that the two mirrors always turn together around the axis of the photometer, and such rotations are read upon the divided disk, S, which serves in addition as a screen, and prevents the direct rays of the lamp, L, to be photometered from falling upon the Bunsen disk.

Figs. 2 and 3 show the apparatus arranged for the

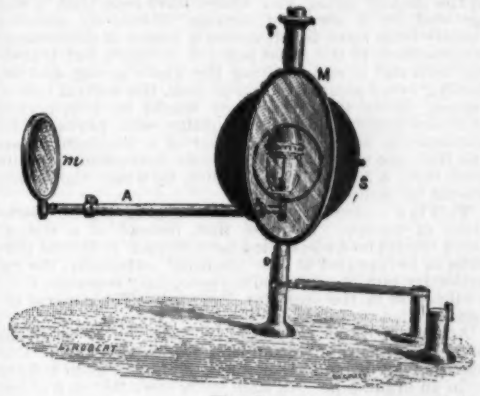

FIG. 2.

measurement of the horizontal and vertical rays of the lamp, L, placed behind and masked by the disk, S. From the structure, it is evident that, when once the luminous ray has been adjusted in the axis of the photometer, it will remain there for all the positions of the arm, A, carrying with it the horizontal axis of the mirror, M.

It is thus possible to effect every relative measurement of the luminous intensity at a given angle. In order to make an absolute measurement, we begin by photometering the lamp, L, by removing the system of two mirrors (this being very easily done on account of the arrangement of the support), and then making the measurement with the mirrors for the horizontal

FIG. 3.

rays. We thus have the factor of reduction by which it is necessary to multiply the intensities found in order to compensate for absorption. Naturally, it is necessary, in the measurement, to take into account the increase of distance produced by the various reflections of the luminous ray.

Preliminary measurements have shown that the absorption by the two mirrors is but 1·8 per cent.—*La Lumiere Electrique.*

A RECENT case is reported, says *Fire and Water*, where a painter engaged in a mill removed his overalls at 6 P.M., to go home. At 8:30 the watchman, discovering smoke in the mill, summoned the engineer, and together they searched the premises carefully, tracing the smoke to a small room in which the overalls were discovered, and in one pocket was a bunch of greasy waste which had ignited. This goes to prove that spontaneous combustion will ensue in less than three hours if the conditions are all right.

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* H. Bouilhet, "Ann. de Chim. et de Phys.," t. xxiv., p. 549, 1881.

† Farbenlehrer.

‡ "Sitzungsberichte der kon. Preuss. Akad. der Wissenschaften," Feb. 16, 1888, and "Phil. Mag.," July, 1888, vol. 26, p. 1.

* He pointed out that the experiment with minium confirmed his view that the mercury calcined in air derived oxygen from the air.

† *Comptes Rendus*, t. lxxxviii., pp. 1108, 1235, et t. lxxxix., p. 465, 1879.

‡ "Ann. de Chim. et de Phys.," t. ix., 1876, p. 56.

§ *Ibid.*, t. xii. 1887, p. 358.

‖ Pionchon, *Comptes Rendus*, t. cii., pp. 675 et 1454, 1886.

** Le Chatelier, *Ibid.*, t. cii., p. 819.

†† Osmond, *Ibid.*, t. cii., pp. 743, 1125.

[FROM CHRISTIAN THOUGHT.]

THE VIBRATORY LAW OF PROGRESS.*

By HORACE C. HOVEY, D.D., Pastor of the Park Street Congregational Church, Bridgeport, Conn.

I SHALL try to explain and illustrate a wise and beneficent law, about whose workings many seem to be perplexed, but that runs through all nature, and affects the human soul in its relation to its Maker—the Vibratory Law of Progress.

My subject came to me in a somewhat singular way. One of my neighbors had celebrated his son's ninth birthday by giving him an instrument of torture, more commonly known as a violin. There I sat in my study trying to gather from the resources of history and science, or else to evolve from the depths of my own consciousness, something worthy of being laid before this Institute; and yonder on his father's porch, just over my fence, sat young Maurice, his calm blue eyes full of gladness, as "from morn till noon, and from noon till dewy eve," he drew the most excruciating sounds from that wretched fiddle.

At length, even as Samson found honey in the lion's carcass, so I found goodness in those discords. You know that, when the flying cannon ball finds its mark, the arrested motion is at once transformed into heat; and by some such correlation of forces, those abortive attempts at music accomplished their mission by suggesting my theme.

Poor Maurice literally "drew his bow at a venture." Before one pulsation of the strings was finished, another would be begun. These incomplete vibrations resulted in confused waves of sound. Had the bow been evenly drawn, there would have been a succession of equal waves of clear sound that might have pleased the listener. Had you, in such a case, looked critically at the shaken string, you would have seen that it was agitated by a series of double vibrations, passing rapidly from right to left across a center of quiescence, not confined to the exact point of contact, but traveling from end to end, exciting the whole string, and deflecting every atom, in its turn, from the central line of repose. More than this, they would be propagated from one sonorous body to another, and pervade the atmosphere, until, in the hands of a Paganini or an Ole Bull, the violin, king of melodic instruments, might pour forth a flood of sweet sounds, by which thousands should be thrilled.

This law in acoustics finds analogies in all the operations of nature. Suppose that, instead of a string, there should be a suspended metallic rod. If lateral percussion be applied at the liberated extremity, the reactionary motion will produce secondary reaction, *i. e.*, a vibration in the opposite direction. The general effect is called undulation.

Apply the same principle to fluids, or to aeriform bodies, and similar phenomena will be observed. For instance, let a column of air be confined, as in a flute or in an organ pipe, and then let it be excited at a given point by a transverse current of air from the lungs or the bellows, and an effect would be produced analogous to that caused by drawing the bow across the violin string. And the law still works, though the column of air be measured by miles instead of by inches. "When the noisy weathercocks rattle and sing of mutation," the shifting vanes show that the gale, instead of being a mass of air impelled in a straight line—and which would therefore be noiseless—is the resultant of conflicting forces to which it alternately yields, swaying to and fro in its mighty march. And when the storm strikes the ocean and uplifts its depths, the rolling billows are but successive vibrations, shifting across a central line of repose; and their awful roar is but the same sound, immensely magnified, as that emitted by the agitated water in a glass bowl whose edge is rubbed by the moistened finger.

It is probable that this law is applicable to all sorts of motion, with the possible exception of primary forces, such as gravitation, cohesion, and chemism. It is applicable to light, heat, and electricity, whether regarded as modes of motion or as attenuated material substances moved by an occult force. The nature of these powerful agents remains enigmatical; yet some highly interesting discoveries have been made. It is known, for example, that those zigzag flashes of lightning whose occurrence is so startling are not due, as it used to be said, to a rebound from compressed atmosphere, but belong to the mode of electrical progress, and are visible even *in vacuo*. We have seen the Ruhmkorf coil flash artificial lightning more than five feet through an exhausted receiver; and the vibratory motion was even more brilliant than is to be seen when

> "Far along,
> From peak to peak, the rattling crags among,
> Leaps the live thunder."

Finer still, if possible, is the working of this law in the transmission of light and heat. The undulatory theory has now gained general belief; but if, for the sake of an illustration, we may blend with one form of this something of the old corpuscular theory, then we shall get a striking result.

It is quite uniformly conceded, at the present time, that all matter, however compact and solid, or however ethereal, is reducible to atoms, *i. e.*, to minute, unchangeable, indestructible particles. It is also held that these atoms are all isolated, and never in any instance come into actual contact, but are firmly held by attraction in their respective positions and at definite distances. It is thought, moreover, that these interspaces are as great as the spaces themselves, and may be largely in excess.

Now suppose a beam of white, solar light to traverse, as it may, the space between the sun and our globe. It then passes through the atmosphere and finally impinges on a prism. On inspection it is found to be, not simple, but compound—a sheaf of rays capable of analysis and subdivision until, if the Newtonian theory were correct, the light would be reducible to atoms as really as is the prism through which it passes.

And now, granting all this, trace, if your imagination be equal to the task, the pathway of one of these luminous monads, assuming it to fly in and out among the coarser atoms, as the bird flies through a tropical forest, without ever beating its wings against the smallest twigs of the interlocked trees. Thus it comes quivering, trembling, vibrating, on its long, mysterious journey from yonder far-distant sun, piercing its way, till at last its divine mission is accomplished in giving the dewdrop its sparkle, the violet its heavenly blue, and the human eye power to behold the beauties of nature and to read the sacred message proceeding from the Father of Lights.

Those huge bodies that wheel so grandly through illimitable space are not disobedient to the law controlling the minutest molecule. For twenty centuries sages have been perplexed by the eccentricities of the single satellite that swings with our earth around the sun, and with the sun on its far longer circuit around some remote cosmic center.

To any careless observer the lunar orbit might appear to be uniformly circular. But ages before the epoch of Copernicus, it had been discovered that the moon moves more swiftly at certain points of its orbit than at others; the point of most rapid motion being termed the perigee, and that of slowest the apogee. Then it was found that the line of apsides, the line passing through the center of the earth and also of the lunar orbit, was itself in rotation, revolving once in nine years. And as to the moon's revolution around the sun, we find it so modified by its motion around the earth, continually folding in upon its own orbit, as to justify our saying that, instead of proceeding with any sort of uniformity, the body sways to and fro in its progress amid the spheres. This complicated behavior of the "inconstant moon" is merely an example near at hand of the known and conjectured irregularities of all the starry host, including even the remotest nebulæ. And we may safely leap to the conclusion, so far as the inorganic universe is concerned, that there is no motion without vibration; or, stated more fully, that whenever a direct forward impulse is given to matter, it is accompanied by lateral, or transverse, impulses seemingly antagonistic, or at least confusing, but that are usually, if not invariably, auxiliary instead.

Let us now pursue our subject in another direction. Nature's methods are uniform, and we shall see, on inquiry, that if she admits co-operation, she will constrain animated beings to conform to her unvarying laws.

Every organism is a duality. And when any living thing is in motion, as a whole, that motion is the resultant of two or more sets of forces under the control of one dominant impulse.

Take the case of the flying bird. Omit the lateral forces—the wings—and the central, or will power, is useless. One of the most pitiable objects I ever saw was an American eagle whose wings had been clipped. The proud bird raised his lordly head, made ready for his customary flight beyond the clouds; and then the gleam died from his fiery eye, his crest slowly sank and his head drooped abjectly, because those means of vibration were lacking that are essential to aerial progress. The lesson, taught by the wren as well as the eagle, appears in one of the sweetest of our childhood hymns:

> "The bird that to our bosom clings,
> In vain we throw on high;
> Unless it wave its little wings,
> It cannot reach the sky."

That which is true of the lower orders of life may also, in a measure, be true of man himself. Look at this haughty lord of creation in one of his most commonplace performances—the familiar exercise of walking. Its dangerous character is proved by what may follow a single misstep, *e. g.*, in going down stairs. Its violent nature is manifested by the consequences of arresting the forward motion against the edge of a door or against a low-hanging bough. Analyze the process, and you will readily see that the operator bears his weight on each foot alternately, meanwhile swinging the other; his arms also maintaining a sympathetic oscillation, a reminiscence, as a Darwinian might say, of the "auld lang syne" when he went on all-fours. The pedestrian thus maintains a central motion, perpetually throwing himself forward, and also a double-action pendulum movement of the limbs, whereby the violent forward motion is prevented from being destructive. Let the vibration cease, even for an instant, and the man falls; as when some mischievous boy twists the long grass into knots across his path, or when, as told in classical story, the fair maiden tripped up the star-gazer with her milking-stool. If, on the other hand, the vibration should be excessive and irregular, as when the brain has been affected by alcoholic stimulus, but little progress is made, and in extreme cases the man falls helpless to the ground. Yet, again, if the oscillation, though disproportioned to the forward movement, should be regularly sustained to the pulse of music, it becomes the very "poetry of motion," and gay and buoyant natures are frequently bewitched by its fascinating peculiarities.

The duality of the human being is manifest in many ways besides in the act of locomotion. Man has not only two hands and two feet, but he has two eyes, two ears, two nostrils, two jaws, two lungs, and indeed is duplex from head to foot; so that, if he should be longitudinally bisected, one half of him would be almost the exact counterpart of the other half; and his very existence, and all his transactions, trivial or sublime, are consequent upon the interplay between these halves of his being.

Going still nearer the fountains of life within man's wonderful and mysterious frame, and inquiring as to the manner in which the will acts on the body, *i. e.*, physiologically regarded, we may adduce the ingenious theory of an eminent Scotch naturalist, as explanatory of the relation of muscular and nervous action: "Our muscles are the seat of two opposing forces, each so adjusted as to counteract the other; and this antagonism is so arranged as to enable us by acting on one of these forces to regulate the other. One force—an elastic or contractile force—is supposed to be inherent in the muscular fiber; another force, that of animal electricity, in statical condition, holds the contractile force in check. When, through the motor nerves, the will orders the muscles into action, that order is enforced by a discharge of the electrical force, and upon this discharge, the contractile force is set free to act." The result is, of course, the bodily motion as previously determined by the will.

But standing on higher ground than mere physiology, it may be affirmed that man has a twofold nature, to disregard which would be both unphilosophical and irreligious. The struggle of life, instead of being simplified, has been complicated by those who deny that mind and matter are different substances though coexistent. A substance is that which underlies a certain set of phenomena, and if there are dual phenomena exhibited in the same life, the conclusion is fair that there is a dual substance to support such phenomena. Body and soul are recognizable by their own characteristic actions, and each is as clearly discernible as the other; and yet they are set in such a peculiar copartnership as to share largely in each other's experiences. They not only share, but fight as to which shall have the largest share. Were matter and mind identical, they would not contend thus sharply for the mastery. Professor Cope says, in his lecture on the Theology of Evolution, that "if we go back to the simplest animal, a drop of jelly, known as the amœba, we find that these very small beings display some mental qualities." He adds that they have no structure at all worth mentioning, and claims that the successive stages of organism can be traced from the amœba to man, every act, from first to last, being a designed act. His grand conclusion is that "mind is the creator of organisms, under the conditions furnished by the environment," and this he regards as "the first step in evidence of the existence of a Great Mind, since the lesser minds must have been derived from some common source."

Partnership, alliance, affiliation—yet constant antagonism! In inspired words: "The flesh lusteth against the spirit, and the spirit against the flesh." Truth also clearly seen by that noble pagan and millionaire Stoic who divided his time between writing Nero's orations and making sermons—Seneca; as proved by that brief sentence to his bosom friend, almost Pauline in its pathos and profundity, *Vivere, mi Lucilii, militare est!* ("To live, O my dear Lucilius, is to fight.") And how many, less righteous than Paul, and less brilliant than Seneca, have found life a hard-fought battle! There have been many cases in real life as strange as "The Strange Case of Dr. Jekyll and Mr. Hyde," or as the weird tales told by Edgar Allen Poe.

It is said that, in passing from infancy to old age, the human body becomes more and more solidified; until, if we only lived long enough, we should be completely mineralized. And so the mind, if it is not fairly dealt by, becomes smothered in its wrapping of flesh; it gets gross by what it feeds upon, until its subtile essence seems hardly distinguishable, having been sadly worsted in the fight. And yet on the other hand, both body and soul may be simultaneously developed, each meanwhile struggling for the mastery, until, in the very nature of things, it becomes evident that there must be a separation, a divorce; and accordingly death benignantly intervenes: "The dust returns to the earth, as it was, and the spirit goes to God, who gave it."

And yet again, not to misrepresent matters, each of these life-long antagonists has really helped the other; neither could have got along without the other; each was needful for the development and best growth and ripening of the other.

Advancing still further in our generalization, let us now consider man in his relations to his fellow-man. His nature is at once individual and social. Could you find a perfect man, he would be both intensely personal and highly philanthropic. Yet by what a struggle is even approximation to such perfection gained!

Only look at man in his happiest social relation, that of the family. How hard it seems for even those of whom the Creator has said, "They twain shall be one," to dwell together unselfishly. How many conjugal conversations are, like poor Maurice's violin playing, a melancholy succession of jarring discords. How many children, also, are treated like little slaves; coming to look on their parents as a sort of "friend-enemies," whom they must obey, and who, in turn, supply them with food, clothing, and shelter, and perhaps send them to school in order to get them out of the way.

And if this be so, what shall we look for in the wider circles of society and politics and international relations? Need we be surprised at corruption, venality, oppression, and every description of public wrong-doing? We are not surprised at it; we expect it, and habitually guard against it.

Yet all thoughtful men know that it is wise for those in public life to make mutual concessions, to exercise mutual forbearance, and to foster charity and all those admirable graces that are so antipodal to man's natural egotism! This was taught by Socrates, Aristotle, and many another sage, on mere considerations of utilitarian expediency. A stronger central impulse was needed, however, to sweep into one channel these belligerent forces; even as the lordly Mississippi bears its thousand tributaries onward to the great gulf. And until this progressive impulse came from above, the earth was everywhere cursed by the most odious despotism, grasping covetousnes, grinding slavery, and frightful degradation. It was the thrice blessed work of Christianity to establish such powerful control over the hearts of individuals as to unite them in a glorious rolling tide, that shall never cease to flow till

> "All men's good shall
> Be each man's rule, and universal Peace,
> Like a shaft of light across the land,
> And like a lane of beams athwart the sea,
> Through all the circle of the golden year."

Practical Christianity effects a reconcilation between liberty and authority. That kind of communism which sinks the individual in the social compact, and would reduce mankind to the dead level of its lowest elements, is as far removed from Christianity as is that other extreme, asceticism, which ignores the claims of society, and shuts its devotees into solitary cells or sends them into self-exile.

We believe in personal liberty, not in the Sunday beer-garden sense, but in the sense that every human being shall enjoy all his inalienable rights. But when the individual sees himself to be surrounded by millions of others made in God's image as much as he himself is, then he is clearly bound to respect their rights, as well as to protect his own. Hence originates the ideal Christianity, not at all visionary or impracticable, but that may some time be realized on earth, in which each individuality shall be marked and emphasized as separate from all others, being distinguished even from God Himself; and yet in which, by voluntary co-operation and submission to rightful authority, these countless individualities shall be unified into one magnificent

* A lecture delivered before the Eleventh Summer School of the American Institute of Christian Philosophy, at Round Lake, N. Y., July 26, 1888.

whole. Even as it is written, "we, being many, are one body in Christ, and every one members one of another."

I wish it might be said with truth that the Church had perpetually and consistently aimed to lift mankind up to this standard. The primitive Church began well, being so organized that all her members were represented in the governmental scheme. Equal power was vested in each citizen of the new Kingdom of Heaven, both as to making and executing the laws. There was community of goods, and therefore an end, for the time being, to the strife between labor and capital. The sweet fellowship of the Gospel was the sole tie, and all else was voluntary. Believers were brethren, and rejoiced to demonstrate that the ethical system of the Gospel could be made also a working system. Yet step by step this delightful brotherhood became assimilated to secular modes, until, amid the darkness of the Middle Ages, the Church itself became the most arrogant, towering, unscrupulous, and unchristian system that ever succeeded in trampling out the spark of freedom from the heart of mankind.

Then came that dreadful storm known in history as the Lutheran Reformation, without which the sky might never have been clear. The lightnings flashed and the thunder rolled, nation hurled itself against nation, and war followed war in the settlement of the momentous questions raised by the daring reformers of the sixteenth century. Even a *resume* of the socialistic theories and Utopias would be voluminous. There is an abysmal chasm between the exalted fraternity of the primitive Church of Plato, of other religious communists, on the one hand, and that naked materialism that discards Christianity as a carcass, and whose reiterated cry is that of the prodigal, "Give *me* the portion of goods that falleth to *me*," and whose promised Paradise is the free satisfaction of individual wants, whether sensual or refined. Truly the whole world has been convulsed to such a chaotic ruin as to make us believe that the only real Utopia must come down from the skies, from the Almighty Hand that made the harmonious stars, and having for its eternal watchword the Golden Rule.

Faith makes us optimists, when else we should be the reverse. Our ears are shocked by incessant explosions. It may be doubted if the historian's pen has ever chronicled bloodier scenes than those witnessed by this boastful generation. And yet our boasting is not wholly in vain. These violent vibrations, by which whole continents are agitated, strike off the manacles of slaves and shake despots from their thrones. These upheavals of society set at liberty the minds and persons of men, clarify the moral atmosphere, and bring up from the depths the granite blocks of truth from which the eternal temple shall be made. Because God reigns, we trust that each battle is a step onward in the line of progress; a step ankle-deep it may be in human gore, but onward, nevertheless, toward a millennium when peace and love shall universally reign.

Fears of anarchy and widespread ruin are groundless. There is a God, and He must rule. Freemen who know His name and His love will voluntarily at last submit to His holy law, until it shall finally be true that

"The whole round earth is every way
Bound by gold chains about the feet of God."

Whatever else may be in doubt, one thing is certain, namely, that true religion is a great leveler. It teaches that all men have equal worth in the sight of their Maker, an equal share in the redemptive work of the Son of God, an equal right to all spiritual blessings, and forbids those invidious distinctions so often growing from an unequal distribution of property. Hence it is axiomatic that Christianity will have as many stanch friends as there are human minds liberated by her power; and as many loyal subjects as she has friends.

Behold this refining and purifying faith! It lifts up the poor man and clothes him in the regal robes of a noble brotherhood; it puts its protecting arm around fragile womanhood, and says, "Be pure and be strong;" it clasps innocent childhood to its bosom, and at the same time accosts with balmy mercy the drunkard and the harlot. Love and gratitude are stronger links than fear and pain! Christianity enters into the whirl of broken relationships, shattered morals, dishonored natures, and clouded souls, and like a mighty moral magnet attracts to itself, in beautiful order, all that is in any way capable of assimilation.

That Garrisonian war-cry, "Agitate, agitate!" was but a recognition of the Vibratory Law of Progress; and concerning every cause of righteous reform, whether the abolition of slavery, the arrest of Mormonism, the prohibition of the terrible traffic in intoxicants, or the righting of any other wrong, the first and greatest danger is that of apathy and stagnation. Agitate, agitate, till that mighty promise is fulfilled: "Yet once more I shake not the earth only, but also Heaven. And this word, yet once more, signifieth the removing of those things that are shaken, as of things that are made, that those things that cannot be shaken may remain."

And now, if we let the pendulum swing from the battle-field we have been surveying into the realm of scientific investigation, shall we find the atmosphere calm and the sky serene? Here may be no passages at arms, no garments rolled in blood, no gleaming swords and thundering artillery; but great is the strife of pens, and tongues, and brains!

Having recently attended a medical convention, my mind turns to that branch of science for an illustration. Passing with slight mention the claims of mind-cure, faith-cure, prayer-cure, and water-cure, as well as many other "cures" that have alike their champions and their critics, we are reminded that no controversy between Papist and Protestant, Calvinist and Arminian, ever waxed hotter than that between the allopathists and the homeopathists. There was a time when the very ground one trod upon seemed to be set with torpedoes, and even now it may be perilous to invite you to take the conflicting theories of *Contraria contrariis* and *Similia similibus*, as illustrating the Vibratory Law of Progress.

No one will dispute, however, that prior to Hahnemann, and within the memory of many now living, the old school had gone to amazing lengths in administering powerful and nauseous drugs. It would almost seem as if the physicians had concluded, seeing that all diseases were to be cured by their opposites, that their patients could not have too much of a good thing. Those were the days when the lancet was applied and blood was officially shed on the slightest pretext, days when calomel, quinine, and tartar-emetic were household words, days when the outer man was scorched with blisters, while the inner man was searched by drastics that might well purge him of everything but his original sin. Beyond all praise was the complacency with which wise physicians would gaze on their tormented patients, and if, perchance, between the remedy and the disease, the soul slipped away into another world, they would join with the preachers in recommending the survivors to wait till their own turn should come.

But Providence is merciful, as well as mysterious, and accordingly the pendulum was allowed to swing to the homeopathic extremity of infinitesimal doses. Instead of swallowing nauseous powders and choking boluses, men were to be cured, forsooth, by tasteless dilution or by the daintiest globules. Some of these contained, however, the most remarkable and unlovely drugs; among which I may quote, on authority, the serous fluid of the living diadem spider; the tincture of the red ant; the tincture of the honey bee's sting; the inky juice of the cuttle fish; and even the hydrophobic virus of the mad dog. The beauty of the system is that these are all to be given in infinitesimal doses. Thus administered, virulent poisons, such as arsenic, belladonna, and strychnine, once regarded as giant forces only to be invoked on extraordinary occasions, have become favorite domestic remedies. I have amused myself by applying a little arithmetic to the subject, and find that the twentieth trituration of brimstone with an inert vehicle, such as sugar, would require a sugar sphere larger than the globe we live upon; and that the thirtieth dilution, or decillionth attenuation, which they sometimes claim to give, would require a thousand times as much water as is found in all our lakes, rivers and oceans! There would certainly be some great advantages in taking strong medicines in their thirtieth dilution. Should it be necessary, in the course of human events, to administer that familiar yet dangerous drug alcohol—and which may yet be found in some of our best drug stores—by all means let the following quasi-homeopathic prescription be followed:

"Take a little rum:
The less you take, the better;
Mix it in the lakes
Of Wenner and of Wetter.
Dip a spoonful out—
Mind you don't get groggy—
Pour it in the Lake
Winnipisiogee.
Stir the mixture well,
Lest it prove inferior;
Then put half a drop
Into Lake Superior.
Then every other day
Take one drop in water;
And you'll be better soon—
Or at least you ought ter."

Now, if any one objects to our making a little fun of the doctors, by way of digression, just let him reflect how many sly jokes they have had at the expense of the preachers. And let me hasten to say, and with all my heart, that I hold the medical profession in high honor, and would by no means charge the follies of any set of extremists on the noble army of physicians.

The point now made is that this swinging from one extreme to the other has really been beneficial and progressive on the whole; so that, in these happier days, the allopathists give as light doses as they dare to, while the homeopathists do not hesitate to give real medicine, in crude and tangible forms, whenever they may think it desirable to do so. And from these and other sources the discovery has dawned on the general public that nature herself has wonderful restorative energies, and that it is the chief office of the skillful physician, of whatever school, to aid her efforts adroitly and sympathetically, meanwhile relying on that divine healing without which nature herself must die.

Turning now to a still graver theme, we may find a final illustration of the Vibratory Law of Progress in its application to the mighty contest going on between science, in its agnostic form, and religion resting on a divine revelation.

We have seen that there is a tendency in nature to keep the equilibrium; so that action is uniformly followed by reaction. It is at least conceivable that there should be a corresponding tendency to spiritual equipose; so that, every evil impulse being checked by a good impulse, the soul should stand upright. But, alas! there is a schism in every soul. Divided against itself, it falls.

The form usually taken by this schism is that of a collision between reason and faith. In one's early years he believes whatever he is told; but after awhile, finding that testimonies are contradictory, he comes to exercise his own judgment. He begins by faith without reason. He next reasons without faith. Happy is he who, finally, uses both faith and reason, each for its legitimate design.

Similar to this individual experience is that of the race collectively. We have long been taught, and have accepted the lesson, that certain things were positively true. But this is a generation that asks questions. It is resolved to push its inquiries boldly to the farthest limits of human thought. The inevitable result is that the vibrations are violent, and many love to have it so. They like to swing!

For instance, it used to be taught that the earth was stationary, while the sun, moon, and stars revolved around it. It used to be taught that the universe was made out of nothing in six literal days, and exactly 6,000 years ago. It still is pretty generally taught, at least in our churches and Sunday schools, that the countless varieties of animated existence were successively spoken into being by a series of creative fiats; and that man himself was fashioned in his full and lordly maturity in a moment of time from the inorganic dust.

Learned men have dared to question these teachings. And on getting from men who are perhaps no wiser than themselves the solemn assurance that it is so taught in the Word of God, they have not been afraid to look into that Holy Book, independently of dictation from priest or layman. And on finding some admitted interpolations, misinterpretations, and seeming contradictions, they have raised anew the inquiry if this is, in very deed, a book from Heaven, and if its teachings are actually infallible.

Men are asking questions of this sort every day and everywhere, and claim the right to do so. And when alarmed conservatists try to arrest or evade such fearless investigations, they too often only embitter men of science, who may next rush indignantly into the ante-chamber of Heaven itself, and ask if there is any God.

Now, however we may condemn irreverence and acrimony, both of which are chargeable, as we regret to say, against some of the leaders of modern scientific thought, we ought to reflect that these inquiries are not in themselves dangerous. Some of them are really necessary. It is perilous to meet them cavalierly or evasively; and such a course tends to drive to the farthest contradiction those whom we should wish to win.

It should be observed, furthermore, that every man, whether friend or foe, renders essential service to religion who pries off from the Bible any merely human theory or doctrine that has been fastened on its pages. For example,, on opening one of our standard cyclopedias, to the article on chronology, you will find it stated that "4004 B. C., the world was created, according to the Hebrew text of Scripture." Now, if a writer for an encyclopedia, or any other man, thinks that he has sufficient reason for assigning to the globe, or the planetary system of which it is a member, an age of but 6,000 years, that is his own affair; but when he says that he is supported in his view by "the Hebrew text of Scripture," we challenge the falsehood. The Hebrew text says nothing about it; nor does any translation thereof. The commonly received date was arrived at, about 200 years ago, by an eminent churchman who used his reasoning powers and reached what he regarded as a satisfactory chronological conclusion. But many men since his day have reasoned too, and quite as well. The result is that, during the last 200 years, no less than 200 different conclusions have been announced as to the age of the race; and by common consent the original date of creation is relegated to the indefinite, unknowable past. Drummond tells us of an experiment in which the gizzard of a gull was so changed by its environment as to resemble that of a barnyard fowl, and instead of an exclusively fish diet, it would eat grain or anything else eatable by pigeons or hens. While the majority of scientists are very sensible men, we mean no offense by saying that certain geological gulls seem to have grown omnivorous by reason of their large environment, and amuse the rest of us by grasping after all they can get. I have heard one eminent scientist assert that man has been a denizen of the globe for a million or two of years, it did not seem to matter which—possibly "for four or five geological epochs;" and have heard several say that the globe itself has rolled through space for at least 100,000,000 of years! Such statements can be nothing but wild conjectures. It is a relief to find that men so justly famous as Sir John Lubbock and Sir J. W. Dawson, the Duke of Argyle, Quatrefages, and our own Dana, think that the actual demands of science may be fairly met by conceding to the race a terrestrial existence of about 10,000 years; while on the other hand, our safest biblical interpreters assure us that, by warrantable modifications of chronology, this much, or even more, might be yielded without bringing the slightest stain on the lustrous page of Revelation.

Now there is one great central force that can adjust aright all decent controversies about the antiquity of the globe, the origin and descent of man, protoplasm, evolution, natural selection, and other matters under daily discussion among men of science; and that force is a *firm, unfaltering belief in the existence of God.* Belief, I say, not demonstration. Kircher, the naturalist, found 6,561 different proofs of the existence of God! And Kant, the philosopher, declared that every one of them involved a contradiction. Suppose, however, that we blend the *a priori* and *a posteriori* arguments familiar to every logician, and rising from the lower court of cause and effect, take an appeal directly to the higher court of intuitional convictions, and affirm the divine existence as an axiom, the basis of all certainty and the reconciler of all antagonisms. I hail the frank statement made by the leading American infidel, that "there is no middle ground between faith in a special Providence and blank atheism." We seek no middle ground! Granting that remotest force which even the atheist cannot deny, we boldly leap to its arms crying, "Abba, Father!"

This doctrine of a special—or better, a particular—Providence, whether taken as demonstrated or as a self-evident proposition, has a wonderful harmonizing power; and that is where it touches our subject. Agnostics may polish their single blocks, whether of marble or of granite, but they leave out the glorious key-stone on which the arch of truth depends for solidity. Science, without a recognition of the Creator, is but a mass of disjointed fragments.

The perfection of intellectual manhood is reached when a wise man determines his doubts in the right direction and adds to erudition a devout recognition of his dependence on a higher power. Perhaps we should not accord such exalted perfection in all respects to the savant who has been styled the father of the telegraph. But, at any rate, few names have been more widely known than his. And how noble was that first of all telegrams dictated by him forty-four years ago, in these words: "What hath God wrought!" At a much later day, when the telegraph had become one of the necessaries of modern life, having crossed the continents and put its long arms under the oceanic billows, Professor Morse was publicly introduced to as brilliant a galaxy of wit and wisdom as could be convened in the city of Philadelphia. Compliments rained on him in a sparkling shower; and when he made his reply, it was simply in these words: "After all, I am but a child of Providence; give God the glory." More wonderful still was that unparalleled spectacle when, on the sunlit sward of Central Park, under the gaze of applauding thousands, the starry flag was lifted from the bronze statue of the great inventor, while superb music hymned his praise, and eloquent lips told the story of his struggles and his victory. Then the wires diverging from New York to the four quarters of the globe were connected, and under the guidance of the sprightly octogenarian, a message was sent to the whole world: "Greeting and thanks

to the telegraphic fraternity. Glory to God in the highest; on earth peace and good will to men." That message was signed by Morse in person. The electric vibrations girdled the globe, and in ten minutes replies came back from America, Europe, Asia, Africa, and the islands of the sea. They found the hero of that memorable day humbly laying his laurels at the foot of the cross.

But all have not the childlike faith of Morse. Many are proud of not having faith, and it never occurs to them to give God the glory. Their boasted agnosticism differs from the humility that says of many a problem in science or morals: "Such knowledge is too wonderful for me; it is high; I cannot attain unto it."

We have spoken of the harmonizing power of faith in a personal God. Look at this in some of its numerous applications, and see how resolutely it steadies the quivering balances and ends the wavering that is so fatal to success. Suppose it to be true that there is a formless substance called "protoplasm" and constituting, as Huxley asserts, "the physical basis of life;" there is, according to this faith, an omnipotent being, who dominates matter by making it instinct with life, and finally subservient to that human soul of whose vitality we have the testimony of consciousness. Suppose that this world has been, as is asserted by Herbert Spencer, evolved from one original germ cell; faith sees the Creator God first fashioning that marvelous germ, and then unfolding its amazingly diversified contents. If it be true, as suggested and argued by Darwin, that man, so immeasurably superior to the brutes, was after all developed from some lower form of existence, then faith sees that development proceed, not by sudden leaps, but slowly tacking to and fro across the ages, with a divine hand at the helm, till the plastic simian is landed in Paradise. If there be indeed a law of natural selection, whereby the best forms of life are preferred to the poorer ones, and are accordingly preserved amid the incessant struggle for existence, then our faith declares that it is God who selects, prefers, and preserves, and that it was by his sovereign choice that man, endowed with reason, conscience, love, and immortality was placed at the head of the terrestrial creation with an immeasurable chasm between himself and all that lies below.

The laws of nature, of which so much has been unwisely said, are not entities, nor even intelligences. They are either forces set in operation by the first cause, or else, as I prefer to think of them, they are simply God's ways of working. Natural phenomena are merely the thoughts of our Heavenly Father. The unfolding rose is one of His thoughts, the glowing sunset is another, the stalactite and the star, the humming bird and the raven, the mammoth and the man—these are simply thoughts of His. "How precious also are Thy thoughts unto me, O God, how great is the sum of them."

With such a vital criterion we may safely walk amid all the zigzag paths into which we are invited by modern science. We not only may, but ought, to take and use everything of real value in every theory that has been invented by the fertile human brain. "Those things that cannot be shaken will remain."

Whatever may have been the mode of creation, the plan is intellectual. All the varied forms of life, and the periods of their appearing, were originally foreordained by infinite wisdom, and we ought not to accuse any devout thinker of having gone over to the skeptical camp, because he reverently entertains the beautiful theory that these forms have come, not by capricious bounds across chasms, but in an orderly manner like the evolution of a plant from its seed. It is time that the word "evolution" should cease to be either a war cry or a shibboleth. I predict the time when students of natural theology will draw their strongest arguments from the very field which so many still regard as strangely overshadowed by a deadly upas tree. Brave thinkers, like Henry Drummond, are doing so already. They will have many glad imitators.

My endeavor has been to show that changes, transformations, all the things that I have grouped as "vibrations," are held under control by a central Law of Progress, to which they themselves are made tributary. The whole cosmic system seems to gravitate toward a coming kingdom foretold in the word of God. As it is written: "Behold I create a new heaven and a new earth." It is conceded by Herbert Spencer that "Evolution has an impassable limit." He speaks of the visible, tangible universe. But, as a believer in the Christian religion, I declare my joyous belief that the same finger of God that has run a central line of orderly progression through all the mutations and oscillations of the present system of things points to higher and grander developments awaiting us in another and a future world. Of that world we have even now bright foregleams, and hope in a few more years to see the full unfolding of its ripened splendors. Meanwhile we would recognize, both on philosophical and religious grounds, the practical lesson that everywhere, whether in the shop, the school, or the sanctuary, man advances, not always with even steps and equal speed, but according to his reception of truth, his sincerity of motives, his convictions of right and duty, his love for his fellow men, and his humble trust in the triune God who stands revealed as our Father, Redeemer, and Sanctifer.

A CURIOUS LIGHT EFFECT IN INCANDESCENT LAMPS.

F. J. CROUCH, of Eugene City, Ore., calls attention, in the *Electrical World*, to the phenomenon presented by an experiment which he recently made and upon which he would like to hear the opinion of others. The accompanying sketch shows the arrangement by which a peculiar light is furnished by the electric current, which light seems to be similar to that of the glow-worm or fire-fly. With three Bernstein lamps he obtained a beautiful moonlight effect, sufficient to read by in a large room.

By reference to the sketch, one may at a glance see how it is produced. M M are the main wires to and from an alternating dynamo, D. From one side of the circuit are hung the lamps, both poles of each lamp being connected together. At the end of this wire is a resistance coil, R, of about 2,000 ohms (or a resistance offered by 80 Bernstein lamps in series), which connects one side of the circuit to the other, which leads to the opposite pole of the dynamo.

Each lamp is placed within a tumbler filled with a strong brine (of common salt), thus partially immersing each lamp. From the bottom of each tumbler a copper wire reaches over the rim and is then connected to the return wire, as shown. Now, when the dynamo is started, the light appears, and the light waves pass through the glass. Is this due to leakage, or is it due

to a static electric effect? Mr. Crouch would be glad to know if this experiment has ever been tried before, and to hear the opinions of others as to the cause of the phenomenon.

SACCHARINE.

By DUJARDIN BEAUMETZ.

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